Feasibility Study of Anaerobic Digestion of Food Waste in St. Bernard, Louisiana

A Study Prepared in Partnership with the Environmental Protection Agency for the RE-Powering America's Land Initiative: Siting Renewable Energy on Potentially Contaminated Land and Mine Sites

Kristi Moriarty

Produced under direction of the U.S. Environmental Protection Agency (EPA) by the National Renewable Energy Laboratory (NREL) under Interagency Agreement IAG-08-0719 and Task No WFD3.1001.

NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

Technical Report
NREL/TP-7A30-57082
January 2013
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National Renewable Energy Laboratory
15013 Denver West Parkway
Golden, CO 80401
303-275-3000 • www.nrel.gov

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List of Acronyms

AD	anaerobic digestion
CHP	combined heat and power
CoEAT	Co-Digestion Economic Analysis Tool
DOE	U.S. Department of Energy
EBMUD	East Bay Municipal Utility District
EPA	U.S. Environmental Protection Agency
LDEQ	Louisiana Department of Environmental Quality
MCRT	mean cell residence times
NAICS	North American Industry Classification System
NPV	net present value
NREL	National Renewable Energy Laboratory
OLR	organic loading rate
O&M	operation and maintenance
RDI	Richard's Disposal Inc.
RFP	request for proposals
SPL	spent potliner
WWTP	wastewater treatment plant

Executive Summary

The U.S. Environmental Protection Agency (EPA) Office of Solid Waste and Emergency Response Center for Program Analysis developed the RE-Powering America's Land initiative to reuse contaminated sites for renewable energy generation when aligned with the community's vision for the site. The former Kaiser Aluminum Landfill in St. Bernard Parish, Louisiana, was selected for a feasibility study under the program. Preliminary work focused on selecting a biomass feedstock. Discussions with area experts, universities, and the project team identified food wastes as the feedstock and anaerobic digestion (AD) as the technology.

The brownfield site is located in Chalmette, Louisiana, adjacent to the St. Bernard Port on the Mississippi River. The brownfield site is 39 acres; however, the center and southern area of the site is a mound with hazardous spent potliner (SPL) wastes. This leaves approximately 19 acres available for development evenly split on either side of the mound. Infrastructure, including rail, water, electricity, and natural gas pipes, are at or adjacent to the site.

Organic food wastes are a significant portion of municipal solids wastes. Only 2.5% are diverted from landfills annually. Wastes were estimated for food manufacturers, supermarkets, restaurants, hospitals, nursing homes, and universities within the area evaluated, including St. Bernard, Orleans, Plaquemines, and Jefferson Parishes. Calculations were based on methodologies developed in past state studies for Connecticut and Massachusetts. There is significant food waste in the area and interest from large producers in alternative waste disposal options. Total food waste generation in the study area is estimated at 70,000 tons per year; however, not all wastes would be available to a project. Assumptions of participation by categories of food waste generators led to a low scenario of 7,000 tons per year and a medium scenario of 15,000 tons per year.

Table ES-1. Estimated Area Food Wastes

Food Waste Producer	St. Bernard	Plaquemines	Orleans	Jefferson	Total
	Tons per Year				
Food Manufacturers	0	150	2,745	995	3,890
Supermarkets	396	164	2,952	6,815	10,326
Restaurants	618	485	23,009	23,253	47,364
Hospitals	0	0	861	399	1,260
Nursing Homes	105	70	1,968	2,531	4,674
Universities	0	0	2,284	0	2,284
Total	**1,119**	**868**	**33,819**	**33,992**	**69,798**

Source: Calculated based on U.S. Census Bureau 2010 County Business Patterns and Massachusetts Food Waste Study[1]

Ideally, wastes would be collected and delivered by private waste haulers. They already have the existing customer relationships, billing systems, and collection equipment. The tipping fee at a bioenergy facility must be lower than the landfill fee ($30/ton) to incentivize food wastes generators to separate organic and inorganic wastes and to motivate garbage haulers to collect and deliver to the

[1] "Identification, Characterization, and Mapping of Food Waste and Food Waste Generators in Massachusetts." Draper/Lennon, Inc. Massachusetts Department of Environmental Protection, September 2002.

facility. This study uses a bioenergy plant tipping fee of $20/ton based on conversations with waste haulers.

Food wastes are an excellent candidate for AD due to high moisture and organic content. AD is the natural, biological degradation of organic matter in absence of oxygen yielding biogas. Biogas is comprised of 60%–70% methane and 30%–40% carbon dioxide and other trace gasses. Biogas is capable of operating in nearly all devices intended for natural gas. AD is commonly used in wastewater and manure treatment facilities. There are few examples of U.S. food waste digesters. A literature review resulted in an expectation of high installation and operating costs for a food waste digester. Average installed and operating costs are estimated at $561/ton capacity and $48/ton processed, respectively.

Financial analysis was conducted using EPA's Region 9 Co-Digestion Economic Analysis Tool (CoEAT). The net present value (NPV), a measure of the profitability of a project, is estimated at -$6.7 million. The lack of profitability is due to very low energy and landfill prices in Louisiana and high up-front costs for anaerobic digester technology and costs for ongoing operations. Revenues from the plant for both scenarios are not anticipated to be sufficient to overcome costs.

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1 Study and Site Background

1.1 Purpose of Study

The U.S. Environmental Protection Agency (EPA) Office of Solid Waste and Emergency Response Center for Program Analysis developed the RE-Powering America's Land intiative to reuse contaminated sites for renewable energy generation. EPA engaged Department of Energy's (DOE) National Renewable Energy Laboratory (NREL) to conduct feasibility studies to assess the viability of developing renewable energy generating facilities on contaminated sites. The former Kaiser Aluminum Landfill site in St. Bernard Parish, Louisiana, was selected for a feasibility study under this initiative.

Biomass was selected as the renewable energy resource, and preliminary work focused on selecting a feedstock. It is generally agreed upon in the biomass industry that sufficient feedstock must be available within 50 miles of a site for economic performance. The site is not located near concentrated woody biomass or agricultural residues. Therefore, area experts, universities, and the project team identified food wastes as the feedstock. They selected anaerobic digestion (AD) as the technology because it can accommodate wet wastes, and food wastes have approximately 70% moisture content. This study will review the site, feedstock, heat and power market, AD technology, and economics of the proposed project.

1.2 Scope of Work

The proposed facility will be an AD system utilizing food waste as feedstock. This feasibility study makes an evaluation of the following areas:

- Site assessment
- Overview of AD technology
- Feedstock assessment
- Markets for heat and power
- Financial analysis.

1.3 Study Area and Site Description

The site is located in Chalmette, Louisiana, adjacent to the St. Bernard Port. The site is in the vicinity of New Orleans, as shown in Figure 1. The circle represents an ideal collection radius of approximately 25 miles for food wastes. Food wastes are 70% moisture, and it is economical to collect waste from nearby producers.

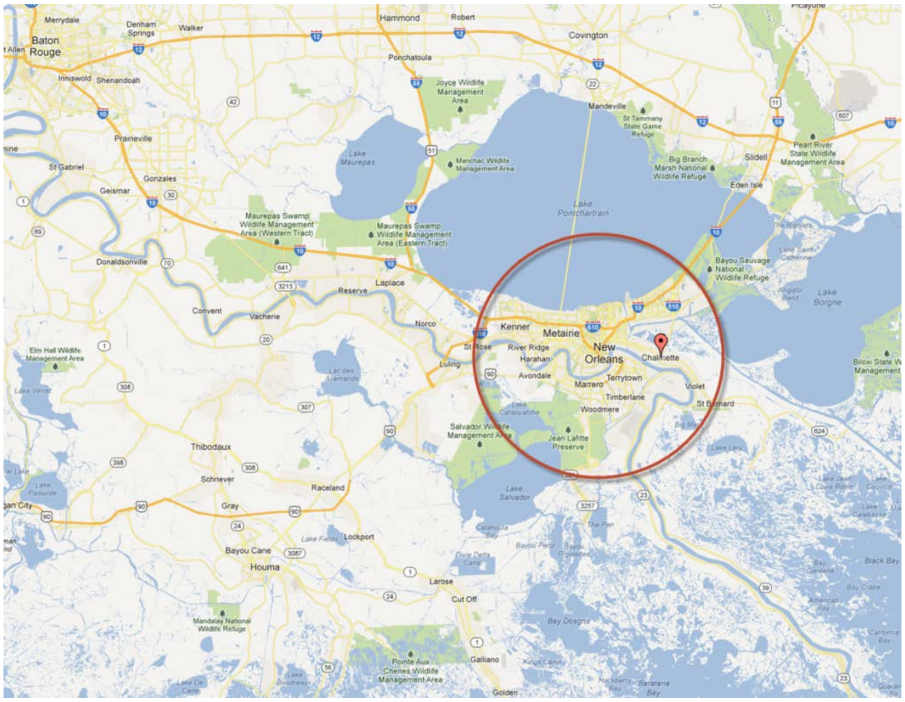

Figure 1. The site in Chalmette, Louisiana. ***Illustration done in Google Maps***

The brownfield site was formerly used as a landfill for spent potliner (SPL) wastes from the Kaiser aluminum facility. The plant was closed in the 1980s, and the landfill was capped. SPL wastes were later classified as hazardous due to cyanide and fluoride content. The site is 39 acres; however, a 25-foot mound containing wastes is located in the center and southern area of the property, covering approximately 19 acres of the site (the yellow area in Figure 2 represents all 39 acres). There is also a fly ash pond and a small unoccupied building in the northeast corner of the mound. The property is bounded by St. Bernard Port, Harbor, and Terminal District in the northeast and southeast; Chalmette National Battlefield and Cemetery in the northwest; and the Mississippi River in the southwest. A detailed drawing of the site is available in Appendix A.

The Louisiana Department of Environmental Quality (LDEQ) and TRC (the land owner) would need to approve any development plans that may impact the cap. The costs to fill the surrounding land to align with the mound would be prohibitive. One option is to use the land on the south side of the mound adjacent to the port as it has easy road access and will not hinder activity at the adjacent National Park Service land.

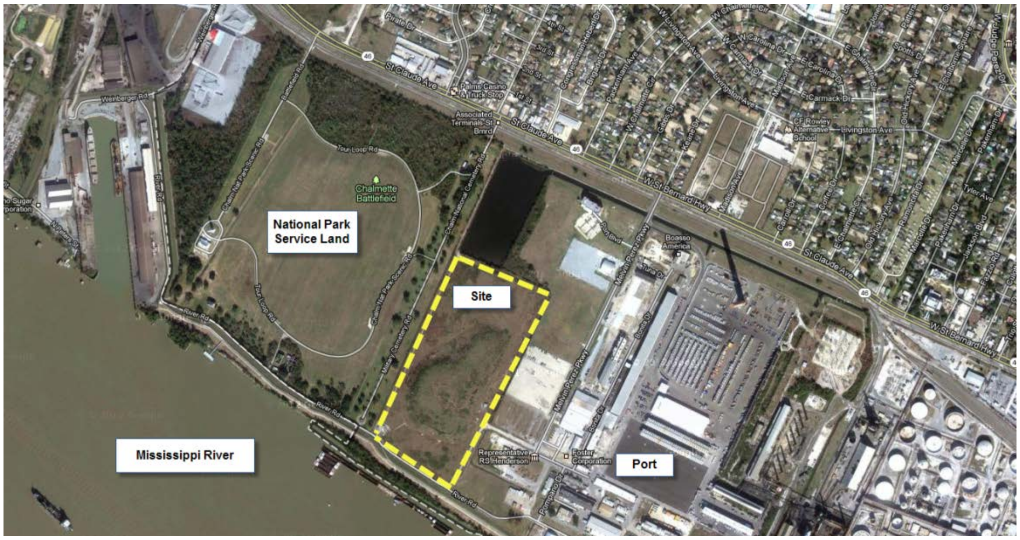

Figure 2. Former Kaiser Aluminum Landfill site. ***Illustration done in Google Maps***

TRC acquired the landfill in a bankruptcy settlement in 2004. They retain environmental liability and are responsible for checking the landfill cap and maintaining the site. There are no future plans to further clean up the site. TRC will donate the property for development while retaining environmental liability if it alleviates their maintenance costs and property taxes.

The terrain of the site surrounding the mound is slightly rolling but should not require greater than normal site preparation and earthmoving.

Figure 3. Photo of the south side of the site. ***Photo by Kristi Moriarty, NREL***

1.4 Site Considerations

The criteria for a successful bioenergy facility include feedstock proximity, road and rail access, state and federal codes, and proximity to required utilities. Another consideration is a market for selling energy from the plant.

The site is located in St. Bernard Parish, approximately 6 miles east of downtown New Orleans and 5.5 miles from Interstate 10. Significant infrastructure exists in the immediate vicinity due to the port, oil refineries, sugar plant, and other industries nearby. The site is accessed by Louisiana Highway 46/St. Claude Avenue, a multi-lane road. Northfolk Southern Railway is located 0.2 miles northeast of the site. The site is adjacent to St. Bernard Port on the Mississippi River with a 45-foot draft. Entergy Louisiana provides natural gas and electrical service, and a tie-in is located 0.2 miles east in the Port. St. Bernard Parish water and sewer services are also available near the port. Resulting biopower will ideally be delivered to end-users via Entergy Louisiana's infrastructure.

Proximity to communities is also an important factor because of increased traffic volume to deliver feedstock and odor. The site is located in an industrial area with no residential communities nearby. The area is accustomed to truck traffic due to petroleum and other industries in the immediate vicinity.

1.5 Federal and State Regulations Impacting Anaerobic Digesters

The size and design of the plant, the method of steam and power generation, and local permitting requirements ultimately affect the actual permits required for an AD project. State agencies generally handle permitting. Some states consider anaerobic digesters a waste processing facility.

The federal regulations and permits required for an AD project include:

- National Emission Standards for Hazardous Air Pollutants covers boilers[2]
- EPA's National Ambient Air Quality Standards says combustion devices must emit below stated levels[3]
- 2011 EPA Clean Air Act pollution standards requires biomass boilers over 10 million Btu/hr for 876 or more hours per year to meet numeric emission standards[4]
- 40 CFR Part 89 limits emissions on non-road internal combustion engines[5]
- 40 CFR Part 60 limits emissions on steam generating units over 10 million Btu/hour[5]
- 40 CFR Part 63 requires reciprocating internal combustion engines or generators over 300 hp to meet specific carbon monoxide standards[5]

[2] http://www.epa.gov/ttn/atw/eparules.html.

[3] http://www.epa.gov/air/criteria.html.

[4] "Final Air Toxics Standards For Industrial, Commercial, and Institutional Boilers at Area Source Facilities." EPA, 2011. Accessed January 9, 2013: http://www.epa.gov/airtoxics/boiler/area_final_fs.pdf.

[5] "Code of Federal Regulations. Title 40. Chapeter 1 – Environmental Protection Agency. Subchapter C – Air Programs. Parts 50-99."U.S. Government Printing Office. Accessed January 9, 2013: http://www.gpo.gov/fdsys/browse/collectionCfr.action?collectionCode=CFR.

- Resource Conservation and Recovery Act Subtitle D covers solid wastes and says the facility may be considered a waste processing facility[6]
- 40 CFR Part 257 sets disposal standards for owners of non-municipal non-hazardous wastes which would include a facility accepting food wastes[6]
- National Pollutant Discharge Elimination System covers what happens to waste water from the facility[7]
- Prevention of Significant Deterioration and construction permits requires any new major source of pollutants to conduct analysis and use best control technologies [8]
- Risk management plan requires new facilities to development a plan if certain chemicals are stored.[9]

The required state permits generally include construction, air, water, and solid waste permits. Some examples include:

- LDEQ
    - Air quality permits
    - Water quality permits; water appropriation permits
    - Solid waste division approval of plans
- State Department of Transportation
    - Highway access permits
    - Possible easement rights
- State Department of Health
- State Department of Public Service.

[6] "Code of Federal Regulations. Title 40. Chapeter 1 – Environmental Protection Agency. Subchapter I – Solid Wastes. Parts 239-282."U.S. Government Printing Office. http://www.gpo.gov/fdsys/browse/collectionCfr.action?collectionCode=CFR.
[7] http://www.epa.gov/compliance/monitoring/programs/cwa/npdes.html.
[8] http://www.epa.gov/NSR/psd.html.
[9] http://www.epa.gov/oem/content/rmp/.

2 Development of Biomass Energy on Brownfield Sites

One very promising and innovative use of contaminated sites is to install biomass power systems. Biopower systems work well on brownfield sites where there is an adequate biomass fuel supply and favorable power sales rates.

The cleanup and reuse of potentially contaminated properties provides many benefits, including:

- Preserving greenfields
- Reducing blight and improving the appearance of a community
- Raising property values and creating jobs
- Allowing for access to existing infrastructure, including electric transmission lines and roads
- Enabling a potentially contaminated property to return to a productive and sustainable use.

By taking advantage of these potential benefits, biopower can provide a viable, beneficial reuse—in many cases generating revenue on a site that would otherwise go unused.

The former Kaiser Aluminum Landfill is owned by TRC, which is interested in donating the site to a potential renewable energy project. For many brownfield sites, the local community has significant interest in the redevelopment of the site and community engagement is critical to match future reuse options to the community's vision for the site.

The subject site has potential to be used for other functions beyond the biopower project proposed in this report. Any potential use should align with the community vision for the site and should work to enhance the overall utility of the property.

Most states rely heavily on fossil fuels to operate their power plants. There are many compelling reasons to consider moving toward renewable energy sources for power generation instead of fossil fuels, including:

- Using fossil fuels to produce power may not be sustainable
- Burning fossil fuels can have negative effects on human health and the environment
- Extracting and transporting fossil fuels can lead to accidental spills, which can be damaging to the environment and communities
- Depending on foreign sources of fossil fuels can be a threat to national security
- Fluctuating electric costs are associated with fossil-fuel-based power plants
- Burning fossil fuels emits greenhouse gases, possibly contributing to climate change.

3 Anaerobic Digestion

3.1 Overview

AD is the natural, biological degradation of organic matter in the absence of oxygen yielding biogas. Biogas is comprised of 60%–70% methane and 30%–40% carbon dioxide and other trace gasses. Biogas is capable of operating in nearly all devices intended for natural gas with minimal adjustments to account for lower Btu content. In the United States, AD is commonly used in wastewater treatment plants (WWTP) and as a method for manure treatment. The technology is commercial and has been deployed in the United States for over 30 years.

EPA hosted a summit for a case study on biodigesters and biogas in 2012.[10] The benefits of AD include renewable energy generation, greenhouse gas emission reductions, reduced water pollution, and a potential revenue stream created from waste. The primary barriers are high capital costs and low biogas prices.

There are several potential utilization options for biogas. Common applications include heat, power, or combined heat and power (CHP). A portion of generated biogas is required to maintain temperature and provide energy for other functions of the digestion process. Remaining energy is available for electricity generation or direct combustion for heating purposes. Biogas is typically used to power a microturbine or reciprocating engine. Combustion and steam turbines are only used in very large systems.

Other potential scenarios for use of resulting heat or power from anaerobic digester include providing space heating for port area buildings or upgrading and compressing biogas for use in fleet vehicles (Figure 4).

[10] "Case Study Primer for Participant Discussion: Biodigesters and Biogas." EPA Technology Market Summit, May 2012. Accessed January 3, 2013: http://www.epa.gov/agstar/documents/biogas_primer.pdf.

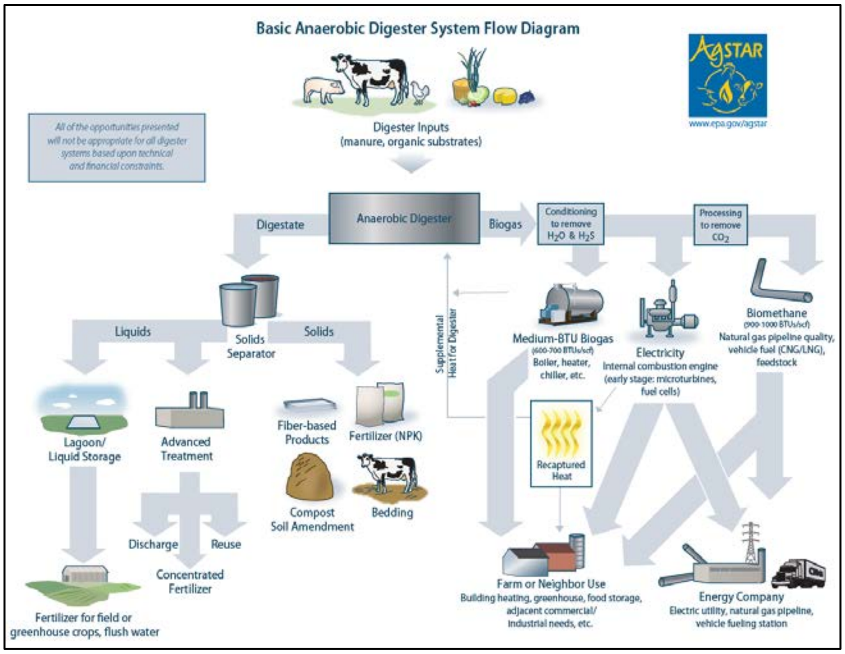

Figure 4. EPA AgSTAR anaerobic digestion uses diagram*. Illustration from EPA AgSTAR Program*

3.2 Technical Information

This project would need to obtain wastes from multiple sources, increasing the risk of contamination. Delivered feedstock may contain silverware, other metals, rocks, and other various non-desirable feedstock components. Preprocessing will be necessary to remove these contaminants from the food waste feedstock. This is done through various methods of sorting, including mechanical systems. The digestion process takes place in a closed environment such as a tank. Digestion results in biogas primarily composed of methane and carbon dioxide. The goal is to produce a biogas with high methane content for energy production. The co-product is digestate and consists of solids and liquids remaining after digestion.

The degradation and conversion process occurs in four steps with different classes of bacteria responsible for each phase. Figure 5 illustrates the microbial process where the first two steps are facultative and the latter two are strictly anaerobic. Operating within defined parameters ensures optimal biogas production.

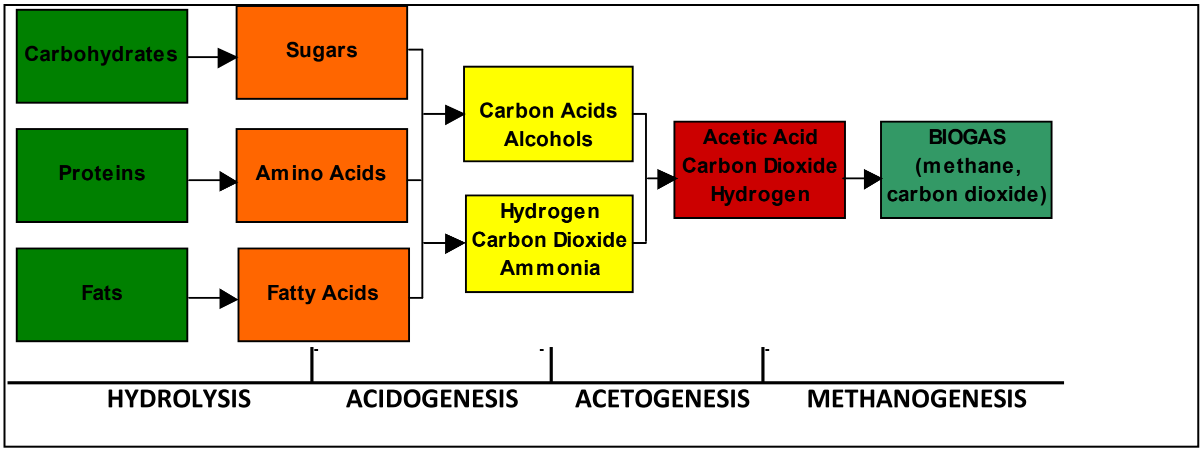

Figure 5. Anaerobic digestion process. ***Illustration by Kristi Moriarty, NREL***

AD technologies are typically optimized for either low solids or high solids content. Alternatively, these technologies are referred to as wet or dry even though the feedstock generally has moisture content above 70%. Low solids refers to wastes with solid content of 3%–10%, and high solids refers to solid content of 15% or more. Wet systems (low solids) mesophilic digesters are the most common and often deployed at WWTPs. Wet digesters slowly mix feedstock with microbes to increase the speed of degradation. Water will need to be added to food wastes in a wet digester to reduce solids content.

There are few examples of food waste digestion in the United States. Existing or planned standalone systems are increasingly evaluating high solids/dry digester technologies. Dry digestion is common for food wastes in Europe. Dry systems can be built to scale-up (batch/modular) as more wastes become available. This may be desirable, as it will take some time to develop the supplier base for food wastes in the study area. The site is not large and several reports suggest dry digestion requires less space. Financing novel technologies is generally more challenging. Any project evaluating AD should engage both wet and dry digester technology vendors.

3.2.1 Digester Types

There are two methods for introducing feedstock into the digester: batch or continuous. In batch systems, the food waste is added to the vessel and sealed for the duration of the AD process. Some technologies integrate composting of remaining digestate co-product in the vessel after biogas production is completed. The more common method is continuous feeding where feedstock is frequently added to the digester. Wastewater and manure AD systems use the continuous method. Dry digesters are either batch or continuous. There is also a variation, temperature-phased anaerobic digester, a two-reactor digester designed to separate microbial processes in order to optimize parameters for different phases. Research has demonstrated that a two-stage reactor leads to higher biogas and methane yields, although dual reactors increase construction and materials costs. Single-stage systems are more common due to lower capital costs.

Complete mix digesters consist of a large above- or below-ground steel or concrete reactor. They are a very common type of continuous digester often used in WWTPs (Figure 6). Waste is mechanically mixed keeping microbes and volatile solids in suspension providing good contact and efficient biogas production. The mixing also provides a homogenous digestate co-product. In the case of food wastes, water will need to be added to reach solids content of 10%–15%. Dry digesters (high solids) are similar in functionality and employ either batch or continuous feedstock entry. Figure 6 and Figure 7 illustrate various AD technology types. A list of technology providers is provided in Appendix B.

Considerations for all digester types include:

- Insulation and heat exchangers maintain temperature from biogas or waste heat recovered from engine exhaust and cooling systems
- Approximately 10% of biogas will be used to provide energy to operate the plant
- It takes time to achieve a steady state for economic methane recovery
- Sewage sludge from a WWTP is often placed in the digester to establish microbial populations prior to loading feedstock.

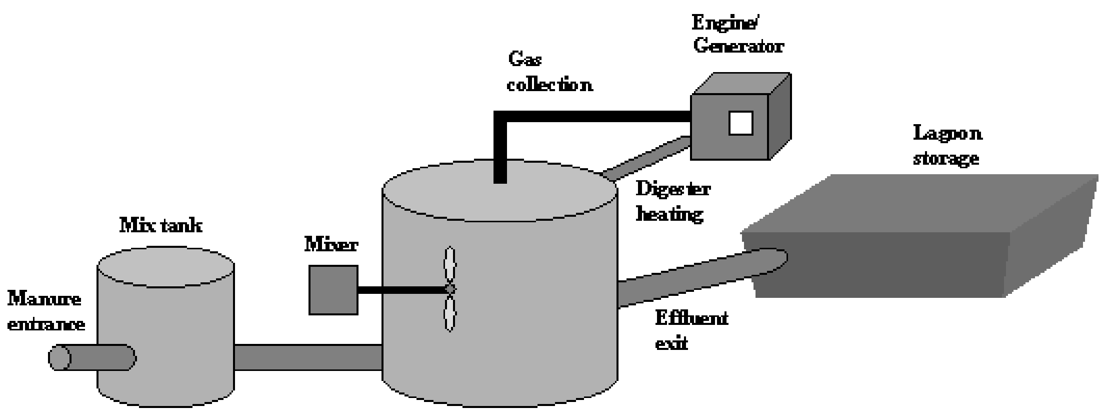

Figure 6. Complete mix digester schematic. ***Illustration from EPA AgSTAR***[11]

[11] EPA. AgSTAR Technical Series: Complete Mix Digesters – A Methane Recovery Option for All Climates. EPA 430-F-97-004. EPA, February 1997.

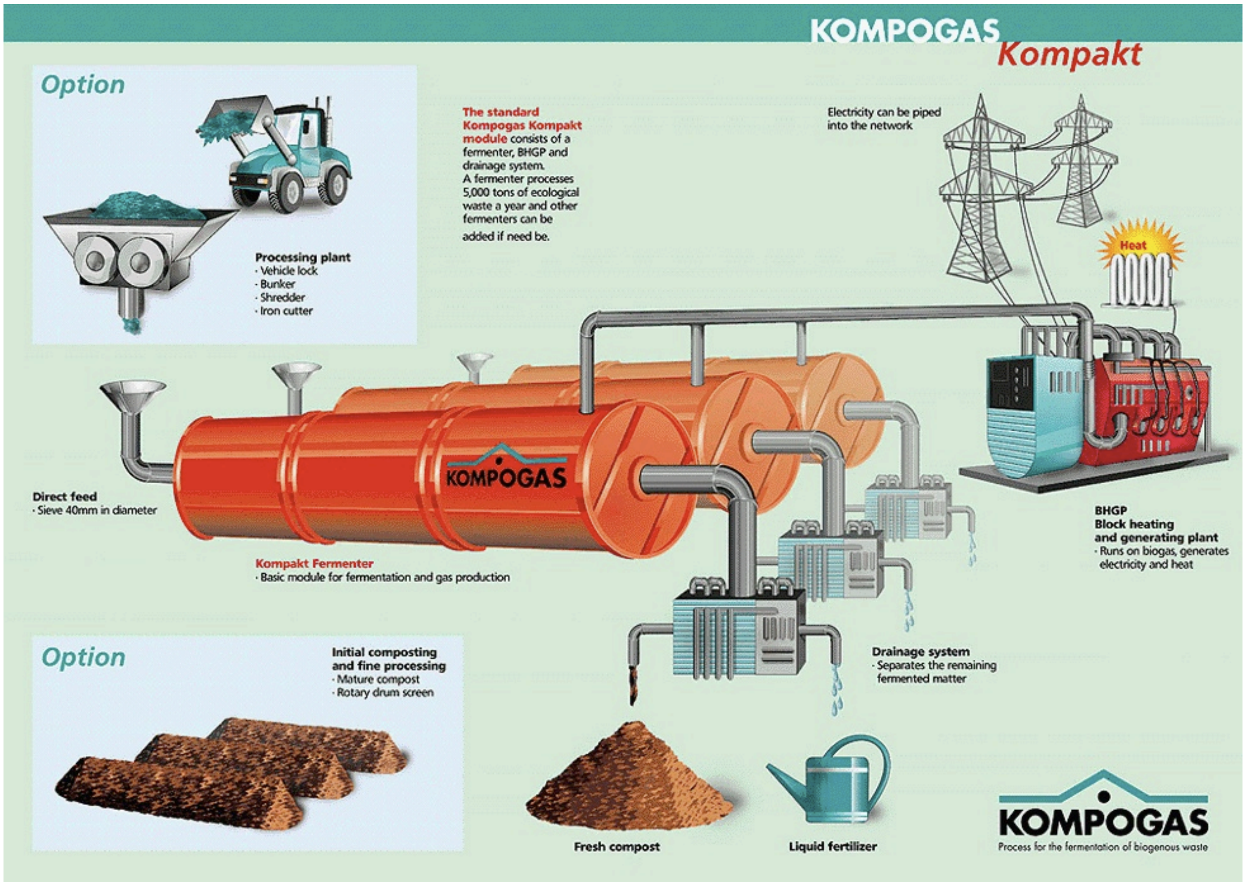

Figure 7. High solids digester schematic. ***Illustration from Kompogas***

3.2.2 Digester Parameters

AD systems are typically designed to operate in one of two temperature ranges: mesophilic and thermophilic. Mesophilic digesters operate between 95°F and 105°F and thermophilic between 125°F and 140°F. Mesophilic digesters are more common due to lower capital costs and ease of operation. Thermophilic digesters produce more energy but are generally more difficult to operate. In the United States, nearly all digesters are mesophilic in use at WWTPs and farms. In Europe, dedicated food waste digesters tend to use high solids (dry) technology and operate in the thermophilic range.

Residence time refers to the length of time for complete degradation of food wastes in a digester. It is a function of feedstock properties, temperature, process system, and similar parameters. Residence time for a wet mesophilic system ranges from 15–30 days. The residence time in thermophilic systems is shorter at about 14 days (wet system) due to higher temperatures. Residence times vary widely with more time generally leading to stable biogas production. However, longer residence time requires a larger digester, increasing capital costs. Engineering design will determine the optimal residence time and size for a project.

Organic loading rate (OLR) refers to the rate at which volatile solids are added to a digester. It is calculated by dividing pounds of volatile solids added to the digester daily by the digester volume. OLR is a function of digester volume and residence time. It is essential to standardize the OLR of volatile solids (about 88% of total solids) into a digester to optimize methane production and minimize risk of a system shutdown. Overloading a digester with organic materials will send a digester into shock leading to reduced or discontinued methane production.

Retention time refers to the average time microbes are in the digester. Methanogenic bacteria grow slower than other bacteria in an anaerobic system. They respond slowly to changes, and AD system parameters should change slowly to maintain methanogen populations in the digester. Overloading solids may result in high levels of ammonia, which are toxic to methanogens.

Optimizing parameters ensures appropriate methanogenic bacteria population to maximize biogas production (Table 1).

Table 1. Anaerobic Digestion Operating Parameters

Parameter	Range	Information
Temperature	95-105°F Mesophilic 125-140°F Thermophilic	The higher end of the mesophilic range is ideal for maximum biogas production
pH	6.5-7.5	Ideal pH is netural at 7.0. Self regulating by anaerobic microbes; methanogens unlikely to grow with pH < 6.5
Alkalinity	0.133 ounce/gallon	Self regulating by hydrogen in waste converting to biocarbonate
Acidity to Alkalinity Ratio	0.3 to 0.5	Easier to measure than VFA or alkalinity
Volatile Fatty Acids (VFA)	<0.013 ounce/gallon	Higher concentrations will inhibit acetate and biogas production
Carbon to Nitrogen Ratio	20 to 30	Higher C:N ratios result in methogens consuming nitrogen; lowering biogas production.
Organic Loading Rate	3-5 kg of Volatile Solids per cubic meter of digester volume per day	Microbes are generally inhibited if loading rate exceeds 6.4 kg/m3 day
Residence Time	9-95 days	Varies widely based on feedstock, temperature, and system design

Source: Loughborough University Biomass Course[12] and EPA Region 2 NorthEast Biogas Presentation[13]

3.2.3 East Bay Municipal Utility District Food Digestion Experiment Results

East Bay Municipal Utility District (EBMUD) co-digests food wastes with wastewater in an existing anaerobic digester. They conducted a study to determine parameters of food wastes in an anaerobic digester at both mesophilic and thermophilic at mean cell residence times (MCRT) of 5, 10, and 15 days (Table 2). The 5-day MCRT did not provide stable biogas production. Methane content is higher for thermophilic operation at both 10- and 15-day MCRTs. The 15-day MCRT resulted in greater methane and electricity production rates. A longer MCRT requires a larger digester.

[12] Biomass Course Book, Loughborough University, 2003.
[13] "Overview of of Anaerobic Digestion and Digesters." EPA Region 2. NorthEast Biogas Webinar, March 24, 2010.

Table 2. East Bay Food Waste Anaerobic Digestion Parameters

Parameter	Mesophilic		Thermophilic		units
	MCRT				
	10 days	***15 days***	***10 days***	***15 days***	
Volatile Solids (% of Total Solids)	89.9	86.3	90.6	87	%
Volatile Solids Loading Rate	0.53	0.28	0.54	0.29	lb/ft^3-day
Chemical Oxygen Demand Loading Rate	1.09	0.55	1.11	0.57	lb/ft^3-day
Volatile Solids Destruction Rate	76.4	73.8	82.4	80.8	%
Methane Content	59	64	60	67	%
Methane Production Rate	9,500	13,300	9,500	13,300	ft^3/lb total solids applied
	2,600	2,300	2,600	2,300	ft^3 per day/ 1,000 ft^3 digester volume
Biosolids (% of food waste entering digester)	31	36	26	30	%
Electricity Production Rate	180	280	180	280	kWh per wet ton
Based on wet digester technology fed at a rate of 100 tons per day of food waste MCRT = mean cell residence time					

Source: East Bay Municipal Utility District Study

The resulting biogas must be treated before it is used to generate heat and electricity. The most significant contaminant in biogas is hydrogen sulfide, which will corrode equipment if it is not treated. An AgSTAR presentation provided costs of $25,000 for hydrogen sulfide treatment equipment (based on 200-kW complete mix wet digester).[14] Biogas must be upgraded prior to entering natural gas pipelines—this requires high capital costs for equipment and significant electrical demand for operating it. Biogas from this project is not expected to enter natural gas pipelines due to Louisiana prices and natural gas supply. Further processing to remove carbon dioxide, hydrogen sulfide, and water allows biogas to be used as a compressed alternative fuel. However, this is a limited but growing market.

Digester heating requirements are influenced by design and insulation used in digester construction. The St. Bernard site is in a warm climate so heating requirements will be low compared with other locations. The waste heat captured in the CHP system will be sufficient to heat the incoming food waste slurry and the digester system. Some of the heat and electricity generated will be used in the plant and administration office.

3.3 Existing AD Systems

There is a long history of AD of wastewater in the United States. According to EPA's 2008 Clean Watershed Needs Survey database, there are 1,455 WWTPs using AD technology. Of these, 104 use CHP technology to heat and power the water treatment process. The WWTPs using CHP technology tend to use reciprocating engine or microturbine technology. Several municipalities co-digest food wastes with wastewater (Table 3).

Nearly all AD projects are owned and operated by municipalities. Many partner with private waste haulers to deliver food waste feedstock. EBMUD used excess AD capacity to produce

[14] "Estimating Anaerobic Digestion Capital Costs for Dairy Farms." 2009 AgSTAR National Conference, February 24–25, 2009, Baltimore, MD.

biogas from food wastes. Their system handles between 7,500 and 15,000 tons per year. Excess power generation is sufficient to provide electricity for 13,000 area homes.[15] EBMUD conducted testing to determine the impact on biogas/electricity production as a result of adding food wastes. They found it significantly increased energy production compared with wastewater. The University of Wisconsin plans to achieve carbon neutrality and deployed a demonstration-scale anaerobic digester using novel technology. The university installed a dry/high solids system with capacity of 6,000 tons per year and power generation capacity of 2,320 MWh per year, representing approximately 8% of university demand.[16]

The towns of Gloversville and Johnston, New York, in partnership with Fage, a yogurt manufacturer, co-digest wastewater and yogurt wastes. Fage selected the location in New York based on available excess capacity in the towns' shared anaerobic digester system. The systems include two 350-kW generation sets.[17] The resulting energy provides 91% of the WWTP's energy needs. Cottonwood Dairy in California installed an anaerobic digester to process manure and wastes from a cheese plant. Electricity and heat are used on-site and excess electricity from the 700-kW unit is sold to Pacific Gas and Electric.[18]

Since 2002, Toronto has used AD to reduce food wastes in landfills and generate energy. As of 2011, capacity is 40,000 tons per year with average biogas production of 3,434 cubic feet/ton.[19] The resulting biogas is upgraded and delivered to a nearby natural gas line. Toronto is expanding and building more AD capacity at other sites with plans to increase annual capacity to 180,000 tons per year.[20]

Several communities are planning food waste digesters. Humboldt County, California is considering a dry system with capacity of 10,000 tons per year. Cedar Grove Composting in Everett, Washington, is seeking permitting for an enormous digester at their existing compost facility with capacity of 280,000 tons per year. Zero Waste Energy Development Company in San Jose, California, is constructing a dry AD system to handle 90,000 tons per year, eventually expanding to 150,000 tons, using a dry/high solids modular design. Harvest Power near Vancouver, Canada, already handles large volumes of food wastes at their composting facility. They intend to build 30,000 tons per year dry/high solids AD system. w2e Organic Power plans to construct an anaerobic digester with capacity of 48,000 tons in Columbia, South Carolina. The

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[15] Gray, D. "Anaerobic Digestion of Food Wastes." East Bay Municipal Utility District. EPA Region 9, March 2008.
[16] "Dry Anaerobic Digestion for University of Wisconsin." *Waste Management World*, July 2011. Accessed October 2, 2012: http://www.waste-management-world.com/index/display/article-display.articles.waste-management-world.biological-treatment.2011.07.Dry_Anaerobic_Digestion_for_University_of_Wisconsin_.QP129867.dcmp=rss.page=1.html.
[17] "U.S. Treatment Plant Converts High-Strength Waste to Energy." *Cogeneration & On-Site Power Production*, January 5, 2011. Accessed January 8, 2013: http://www.cospp.com/articles/print/volume-12/issue-3/project-profiles/us-treatment-plant-converts-high-strength-waste-to-energy.html.
[18] "Joseph Gallo Farms Dairy 700 kW Reciprocating CHP System." Pacific Region CHP Application Center, 2006. Accessed January 8, 2013: http://der.lbl.gov/sites/der.lbl.gov/files/dercam_casestudy_josephgallofarms_v1_2.pdf.
[19] "Digesting Urban Residuals Forum Highlights." CalRecycle, May 2012. Accessed January 8, 2013: http://www.calrecycle.ca.gov/Organics/Conversion/Events/Digesting12/CaseStudies.pdf.
[20] "Update on Anaerobic Digester Projects Using Food Wastes in North America." Institute for Local Self Reliance. City of Atlanta, October 2010.

State of South Carolina will buy power generated by the digester. The company is in planning phases to build a food waste digester in Baton Rouge, Louisiana.[21]

Table 3. Existing U.S. Food Waste AD Projects

Anaerobic Digester Owner	City	State	Feedstock	AD Type
Food-Waste-Based Digesters				
Gills Onions AD Project	Oxnard	CA	Pre-consumer food wastes	Wet
San Jose Zero Waste (construction)	San Jose	CA	Food wastes, green wastes	Dry (Kompoferm)
Orange County Food Waste Pilot Plant	Orange	CA	Post-consumer food wastes	Wet
Monterey Zero Waste AD Pilot Plant	Monterey	CA	Post-consumer food wastes, green wastes	Dry (Kompoferm)
Inland Empire-Environ AD project	Chino	CA	Pre-consumer food wastes	Wet
University of Wisconsin	OshKosh	WI	Food wastes, green wastes	Dry (Bioferm)
City of Toronto	Toronto		Food wastes	Wet
Co-Digesters-Waste Water and Food Wastes				
Gloversville and Johnston	Johnston	NY	Waste water, yogurt factory wastes	Wet
Cottonwood Dairy		CA	Manure, cheese wastes	Wet
East Bay Municipality	Oakland	CA	Waste water, food wastes	Wet
Sacramento County Co. Regional WWTP	Sacramento	CA	Waste water, food wastes	Wet
Central Marin Station	Marin	CA	Waste water, food wastes	Wet
Humboldt County Waste Authority		CA	Waste water, food wastes	Wet
City of Riverside	Riverside	CA	Waste water, food wastes	Wet

Source: CalRecycle[22] and ISLR Study[23]

Europe has more experience with food-waste-based digesters. As of 2006, there were 127 operational food waste anaerobic digesters, with capacity of 4.6 million tons.[24] This is due to a European Union Directive requiring diversion of 65% of 1995 levels of organics from landfills. The three most common technologies deployed in Europe are manufactured by Valgora, Ros Roca, and Kompogas.

3.4 AD Co-Products

The AD process produces a co-product commonly referred to as digestate. Digestate consists of biosolids (~30%) and liquids (70%).[25] It is common to separate solids and liquids. Liquids are typically applied directly to agricultural lands as a low-grade fertilizer. Solids are either composted (EPA's preferred method) or used as animal bedding. Co-products can be separated using centrifuge, heat/drying, or a screw press. Economic values for digestate products are unknown. Many digesters are farm based, and digestate liquids and solids are used on-site. The properties of digestate are shown in Table 4.

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[21] "DHEC Approves Permit for Waste-to-Energy Plant." *Colombia Regional Business Report*, January 17, 2011. Accessed January 7, 2013: http://www.columbiabusinessreport.com/news/37706-dhec-approves-permit-for-waste-to-energy-plant.

[22] "Digesting Urban Residuals Forum Highlights." CalRecycle, May 2012. Accessed January 8, 2013: http://www.calrecycle.ca.gov/Organics/Conversion/Events/Digesting12/CaseStudies.pdf.

[23] "Update on Anaerobic Digester Projects Using Food Wastes in North America." Institute for Local Self Reliance. City of Atlanta, October 2010.

[24] Arsova, L. "Anaerobic Digestion of Food Waste: Current Status, Problems and an Alternative Product." University of Colombia, May 2010.

[25] Alexander, R. "Digestate Utilization in the U.S." *BioCycle*, January 2012. Accessed January 7, 2013: http://www.biocycle.net/2012/01/digestate-utilization-in-the-u-s/.

Table 4. Digestate Characteristics

Parameter	Digestate Content
Total Solids	6%
Volatile Solids	69%
pH	7.6–8.8
Carbon to Nitrogen Ratio	1.5:1
Nitrogen	15%
Potassium	4.70%
Phosphorus	0.70%
Calcium	0.34%
Sulfur	0.30%
Magnesium	0.19%

Source: WRAP[26]

[26] "New Markets for Digestate from Anaerobic Digestion." WRAP. ISS001-001, August 2011. Accessed on January 8, 2013: http://www.wrap.org.uk/sites/files/wrap/New_Markets_for_AD_WRAP_format_Final_v2.c6779ccd.11341.pdf.

4 Feedstock Evaluation

The St. Bernard site is not close to concentrated production of woody biomass or agricultural crop residues. While both are available in Louisiana, minimal quantities are within a 50-mile radius of Chalmette—the desired distance for economical delivery of biomass. The greatest volume of biomass in the immediate area is organic food waste. Waste Management, the leading U.S. private waste hauler, stated that 80 million tons of organic wastes are produced annually. According to EPA, food wastes are the top material sent to landfills, and only 2.5% are collected and diverted annually. A University of Texas study estimates U.S. food wastes could be diverted from landfills to produce 4,900 trillion BTU of energy.[27]

Food wastes are rich in organic matter and are troubling in landfills as they release methane, a potent greenhouse gas. Energy generation, including AD, is an industrial use of food recovery (Figure 8). Several municipalities across the United States offer either household or commercial collection of food wastes. In addition, there are many private organic recycling companies across the United States collecting and receiving organic wastes.

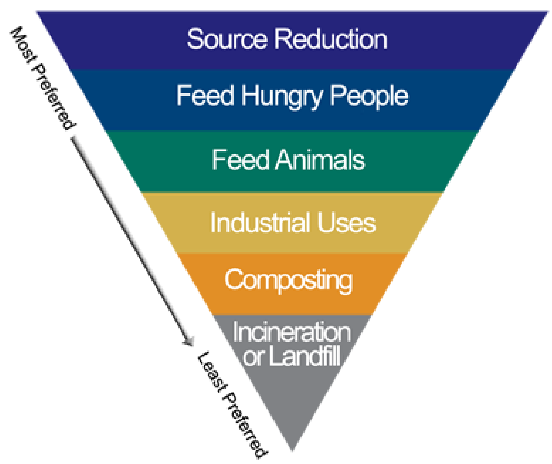

Figure 8. EPA food recovery hierarchy. ***Illustration from EPA***[28]

Many different facilities produce significant food waste volumes, including restaurants, food manufacturers, hospitals, universities, and supermarkets. Healthcare facilities, universities, and conference properties produce similar wastes streams comprised of typically 50% fruit/vegetables and 50% protein (meat, fish, and poultry) and baked goods. Restaurant food waste exhibits more variability in composition. Fast food restaurants often use prepared portions of food and tend to generate less waste during preparation. Restaurants preparing food as it is ordered are likely to generate largely fruit and vegetable wastes with minimal amounts of bakery, sugar, starch, and dairy products. Supermarket waste is mostly produce (90%) with small amounts of bakery, seafood, and deli wastes. Supermarket meat wastes are generally collected by rendering facilities.

[27] Cullar, A.; Webber, M. "Wasted Food, Wasted Energy: The Embedded Energy in Food Waste in the United States." University of Texas, July 2010. Accessed January 7, 2013: http://pubs.acs.org/doi/pdf/10.1021/es100310d.
[28] EPA. OSW Food Waste. Accessed January 8, 2013: http://www.epa.gov/waste/conserve/foodwaste/.

The Massachusetts Department of Environment Protection funded a study to identify and characterize food waste generators.[29] The study established a database of food waste generators and estimated volumes. Massachusetts evaluated 5,800 generators in 10 different categories producing 880,000 tons of food waste annually. The study found that 20% of waste producers generate 80% of the total. Food manufacturers, restaurants, and supermarkets produced the highest volumes. The study determined that there is no method to accurately predict food wastes from a single facility. Food waste generation varies widely even among similar facilities. Large food manufacturers tended to already have food waste diversion programs in place—either selling as livestock feed (commercial bakery wastes) or composting to combat the high cost of trash removal. Connecticut conducted an earlier study that found somewhat similar rates of food waste generation; however, fewer categories were analyzed and restaurants were not included.[30]

Food wastes have high moisture content and are often the wettest component of household garbage (Table 5). The energy content is a function of the type of food waste but ranges between 1,500 and 3,000 BTU per pound of waste. The energy content determines how much bioenergy can be produced from a feedstock.

Table 5. Food Waste Characteristics

Food Waste Characteristics	
Moisture Content	70%
Energy Content	1,500-3,000 Btu/lb
Density	2,000 pounds per cubic yard

Source: Waste Age[31]

4.1 Methodology and Study Area Organic Waste Generation

Organic food waste residues were calculated based on U.S. Census Bureau data and calculations available from the previous Connecticut and Massachusetts studies.[29,30] Seafood processors, universities, and hospitals were contacted. All expressed interest in separating organic wastes, but few could provide estimates of food waste generation.

Formulas for determining food wastes were identified in the Massachusetts study. The referenced study conducted a survey to determine food manufacturer wastes. This study uses the same calculation for food manufacturers, grocery stores, and restaurants assuming 3,000 pounds of waste each year per employee (based on Massachusetts study). A few large sources were able to estimate their wastes and those are summarized later in this section.

Formula for organic food wastes from food manufacturers, grocery stores, and restaurants:

Organic food wastes (lbs/year) = number of employees * 3,000 (lbs/employee/year)

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[29] "Identification, Characterization, and Mapping of Food Waste and Food Waste Generators in Massachusetts." Draper/Lennon, Inc. Massachusetts Department of Environmental Protection, September 2002.
[30] "Identifying, Quantifying, and Mapping of Food Residuals from Connecticut Businesses and Institutions." Draper/Lennon, Inc. Connecticut Department of Environmental Protection, September 2001.
[31] Waste Age. "Profiles in Garbage: Food Waste." September 2000. Accessed January 7, 2013: http://waste360.com/mag/waste_profiles_garbage_food.

Food wastes from hospitals and nursing home/rehabilitation/mental health facilities were estimated using exact and average number of beds. Each hospital reports number of beds. Exact number of beds for nursing homes and similar facilities are not available. The Center for Disease Control reports that the average number of beds in a nursing home is 106.[32] Food wastes from universities with dining halls were based on the number of students and meals per year. The number of meals and food waste per meal were based on Massachusetts's data.

Formula for organic food wastes from hospitals and nursing homes:

> Hospital food waste (lbs/year) = # of beds * 5.7 (meals/bed/day) * 0.6 lbs (food waste/meal) * 365 (days/year)
>
> Nursing home food waste (lbs/year) = # of beds * 3 (meals/bed/day) * 0.6 lbs (food waste/meal) * 365 (days/year)

Formula for organic food wastes from universities:

> University food waste (lbs/year) = # of students * 0.35 lbs (food waste/meal) * 405 (meals/student/year)

The Census Bureau identifies types of businesses using numerical codes known as the North American Industry Classification System (NAICS).[33] This study evaluated business categories, including food manufacturing, grocery stores, restaurants, and health care facilities, and reviewed 2010 company data in Jefferson, Orleans, Plaquemines, and St. Bernard Parishes. Only facilities with 10 employees or more were included in the evaluation. Smaller facilities were eliminated due to the expectation of low volumes and insufficient staff to separate wastes.

NAICS reports the number of facilities for a particular type of establishment for several categories of employment size (Table 6). Because exact number of employees per establishment is unknown, the average number of employees per employment class size was used. As an example, there are seven grocery stores in Orleans with between 10 and 19 employees (see Appendix A). The average employment in this category is 14.5 jobs leading to estimated employment at these seven stores of 101.5 total employees.

Table 6. NAICS Employment Size Class

	Employment Class Size						
Employment Categories	1–4	5–9	10–19	20–49	50–99	100–249	250–499
Average # of Employees	2.5	7	14.5	34.5	74.5	174.5	374.5

Source: Census Bureau[34]

[32] "FastStats Nursing Homes." Center for Disease Control. Accessed September 27, 2012: http://www.cdc.gov/nchs/fastats/nursingh.htm.
[33] U.S. Census Bureau County Business Patters. 2010 Data. Accessed September 2012: http://www.census.gov/econ/cbp/index.html.
[34] U.S. Census Bureau County Business Patters. 2010 Data. Accessed September 2012: http://www.census.gov/econ/cbp/index.html.

4.2 St. Bernard Area Food Wastes

The following parishes were evaluated for food waste generation: Jefferson, Orleans, Plaquemines, and St. Bernard (Figure 9). Table 7 identifies the numbers of businesses producing food waste by category for each parish. Table 8 shows estimated food wastes. Additional details are available in Appendix A.

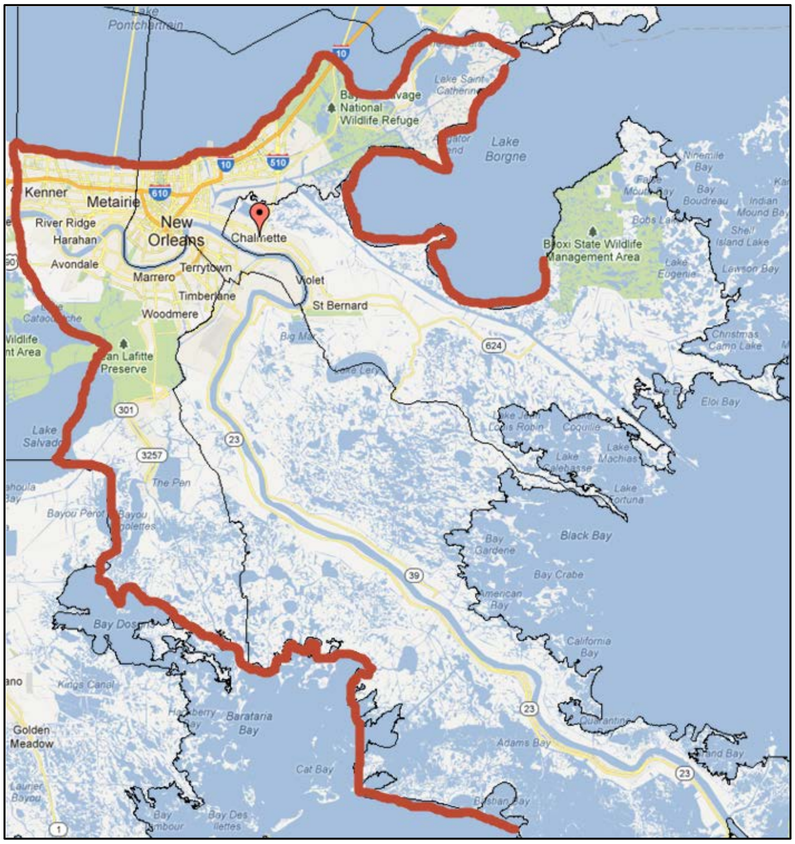

Figure 9. Food waste evaluation area. ***Illustration done in Google Maps***

Food wastes are estimated and do not provide an exact volume of wastes generated in the immediate area. Average food waste per facility is not a good indicator of feedstock availability as it is typical for a few large generators to provide a large portion of the total. If this project advances, the developer should conduct a food waste survey with area producers to determine an accurate assessment.

Any food waste collection project will only capture a portion of available wastes. For example, collecting feedstock from some businesses will not be viable due to insufficient staff for separating wastes or space constraints limiting the ability to accommodate an additional bin.The best case is to work with large waste generators targeting food manufacturers and universities first. These food waste generators showed interest in the project, produce predictable volumes of waste, and are likely to have less contamination than restaurants.

Table 7. Food Waste Producers in Study Area

Facility Type	Number of Establishments With More Than 10 Employees			
Organic Waste Producer	***St. Bernard***	***Plaquemines***	***Orleans***	***Jefferson***
Food Manufacturers	0	1	20	14
Grocery	7	2	24	43
Restaurants	16	14	382	436
Hospitals	0	0	6	4
Nursing Homes	3	2	56	72
Universities	0	0	4	0

Source: U.S. Census Bureau 2010 County Business Patterns; businesses with more than 10 employees.

Table 8. Estimated Food Wastes in the Study Area

Food Waste Producer	St. Bernard	Plaquemines	Orleans	Jefferson	Total
	Tons per Year				
Food Manufacturers	0	150	2,745	995	3,890
Super Markets	396	164	2,952	6,815	10,326
Restaurants	618	485	23,009	23,253	47,364
Hospitals	0	0	861	399	1,260
Nursing Homes	105	70	1,968	2,531	4,674
Universities	0	0	2,284	0	2,284
Total	**1,119**	**868**	**33,819**	**33,992**	**69,798**

Source: Calculated based on U.S. Census Bureau 2010 County Business Patterns[35] and Massachusetts Food Waste Study[36]

Determining how many facilities would participate was not within the scope of this study. However, several universities, hospitals, and food manufacturers expressed interest when initially contacted. Table 9 shows potential volumes based on obtaining portions of the estimated food wastes in each category. Food waste collection scenarios are based on some individual contacts with food manufacturers, hospitals, and universities. Restaurants, supermarkets, and nursing homes were not contacted and their interest level is unknown. A project developer will need to work with waste haulers and facilities in each category to obtain waste. Actual collection of food wastes may vary greatly from levels suggested in Table 9. These numbers were generated to provide a basis for financial modeling of an AD system.

Initial participation will likely be low, and separating wastes is not a common practice in the area. As an example, recycling was reintroduced in 2012 as it was suspended after Hurricane Katrina in 2005. Presumably, participation would grow over time as more facilities are aware and if there are incentives for separating wastes. It is possible to design an anaerobic digester system to be modular and add more capacity as needed. Biomass energy project economics generally improve with greater volumes of feedstock.

[35] http://www.census.gov/econ/cbp/index.html.

[36] "Identification, Characterization, and Mapping of Food Waste and Food Waste Generators in Massachusetts." Draper/Lennon, Inc. Massachusetts Department of Environmental Protection, September 2002.

Table 9. Potential Food Wastes Collection Scenarios

Food Waste Producer	Low Scenario		Medium Scenario	
	% Obtained	Estimate (tons/yr)	% Obtained	Estimate (tons/yr)
Food Manufacturers	20%	778	30%	1,166.85
Supermarkets	10%	1,033	25%	2,581.5
Restaurants	10%	4,736	20%	9,472.8
Hospitals	20%	252	50%	630
Nursing Homes	5%	234	10%	467.4
Universities	25%	571	50%	1,142
Total (tons per year)		7,604		15,461

4.2.1 Food Manufacturers

There are several large food manufacturing facilities in the area. Folgers Coffee plant in New Orleans produces Folgers, Dunkin Donuts, and Millstone brands. Current coffee wastes are 40–50 tons per month (data provided by a private consultant). Folgers closed other plants in the United States to consolidate production in New Orleans and another site in Louisiana. Production is set to expand, which will lead to additional wastes. The Census Bureau reports an additional four coffee and tea production facilities in the study area.

According to a private unpublished area study, there are five large seafood processors averaging wastes of 20 tons per month. Orleans Parish has several commercial bakeries, including Bunny Bread, which produces between 8 and 16 tons of waste per month, which is sometimes used as livestock feed. The Census Bureau reports a large dairy manufacturer with more than 250 employees in Orleans. There are also animal slaughtering operations and meat processors. Targeting the largest food manufacturers in the area is important as the waste will be predictable with no or low contamination.

4.2.2 Grocery Stores

Southern Louisiana is characterized by independently owned grocery markets. Chains are rare, although Rouses and Breaux Marts have several locations. Wal-Mart and Sam's Club also have a presence in the area with estimated wastes per store of 13 tons per month according to Waste Management.[37] Waste Management's study also found southeastern chains Publix and Winn Dixie to produce 9 tons per week. Costco expects to open a store in New Orleans sometime in 2013 and could be a potential source for food wastes. Jefferson has the largest estimated grocery store wastes followed by Orleans.

4.2.3 Restaurants

The restaurant business is growing with 1,313 restaurants in New Orleans and the surrounding suburbs, up considerably from the 809 the day prior to Katrina.[38] The majority of food wastes come from food preparation, but post-consumer wastes are also available. Many restaurants in the French Quarter are space-constrained and would require use of a smaller bin with regular pickup service. Restaurants represent the largest volume of wastes compared to other categories

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[37] Waste Management Organics Overview, January 27, 2011.
[38] The New Orleans Menu. http://www.nomenu.com/joomla1/. Personal communication with Tom Fitzsimmons August 14, 2012.

but also the greatest number of establishments. It will be crucial to properly train restaurant staff—particularly as dish washing has high turnover. Staff will need to understand which items are appropriate for a food recycling bin. There is competition for this resource as NOLA Green Roots, LLC collects food wastes from residents and businesses on 1-, 3-, and 5-day per week pick-up schedules.[39] They currently have 11 businesses composting waste—mostly restaurants but also Loyola University. NOLA Green Roots composts wastes and sells 25-pound bags of compost for $12.99. There are plenty of wastes to accommodate more than one food waste facility.

4.2.4 Hospitals

There are 10 hospitals in the study area—all are located in Orleans and Jefferson Parishes. Several hospitals were contacted and are interested in potential food waste recycling. None were aware of their current waste volumes. Ochsner Hospital has the most beds and therefore the most food wastes followed by Touro, East Jefferson, and Children's Hospitals.

4.2.5 Nursing Homes

Nursing homes, including homes for elderly, mental health, and other rehabilitation patients, were evaluated. These types of homes are concentrated in Orleans and Jefferson Parishes with 56 and 72, respectively. During a detailed feedstock analysis, it would be valuable to determine facilities with the most beds and highest capacity.

4.2.6 Universities

All area universities are located in New Orleans. Each university was contacted to gauge their interest in food waste recycling and estimated volumes. All universities are interested in participating. All of the campuses have cafeteria facilities. Tulane and University of New Orleans have the largest student population. Loyola University is separating food wastes for a privately owned compost facility. Only Tulane provided estimates of food wastes. Bruff Commons Hall generates 16–22.5 tons per week for 9 months each year. The Student Union generates mixed wastes (without recyclables) of 7.9 tons per week during the academic months and 4.25 tons in summer months. Area community colleges are unlikely to have dining facilities.

4.2.7 Other Area Food Wastes

The convention center and sporting arenas are other potential sources of waste. Some conferences, particularly those related to environmental activities, are starting to request that conference venues provide recycling and composting bins. Food wastes from the convention center and sports arenas will be variable based on when events occur, number of attendees, and types of meals served. There are several food wholesalers in the area. Wholesalers tend to deliver pre-packaged items and generate few wastes. Area food banks may have spoiled produce available for collection.

4.3 Potential Business Scenarios

While a waste-to-energy facility can purchase trucks, hire drivers, and establish contracts with restaurants, food manufacturers, and others, it may make more sense to establish agreements

[39] NOLA Green Roots and Composting Network. Accessed September 25, 2012: http://compostingnetwork.com/site/.

with existing waste haulers to collect and deliver food wastes. They have existing contracts with food waste generators, and this will ease the task of billing food waste generators. This is how Los Angeles handles their restaurant food waste collection program. Biomass plants have feedstock delivered by haulers.

There are three waste haulers servicing the greater New Orleans area. SDT Waste and Debris Services (now Progressive Waste Solutions) collects waste from all of St. Bernard Parish, the French Quarter, and the central business district. They are actively growing their recycling program (e.g., aluminum and plastics) and are interested in collecting organic wastes. SDT collects wastes from all New Orleans universities and hospitals. They stated that a typical front-loading truck has capacity for 30 tons, but they are not aware of any composting or other recycler sites able to handle large volumes. This company is proactive and has staff dedicated to growing alternative waste streams and diverting from landfills. Richard's Disposal Inc. (RDI) picks up wastes in Algiers, Esplande Ridge, Garden District, Mid-City, Treme, and Uptown. RDI did not respond to multiple inquires. Metro Disposal collects wastes in East New Orleans, Gentilly, Lakeview, and the 9th Wards. Metarie and Kenner are handled by IESI and Allied Waste Services. Collection rates vary among haulers. Restaurants with 3-cubic-yard bins picked up 6 days a week pay between $225–$275 per month.

Area landfills include Environmental Operators in Venice; River Birch and Highway 90 in Avondale; and Gentilly in New Orleans. All offer similar tipping fees of approximately $30/ton. According to Waste & Recycling News, Louisiana has the eighth lowest average tipping rate among U.S. states in 2012. A food waste project will need to charge less than $30/ton. The lower fee is necessary to incentivize waste haulers to collect and deliver food wastes to a separate facility. Food waste generators also need a financial incentive to motivate them to separate wastes. Based on conversations with waste haulers and close proximity of landfills to New Orleans, a tipping fee of $20/ton is likely to motivate separation and delivery of food wastes.

4.3.1 Example: Los Angeles Restaurant Organic Food Waste Recycling Program

As an example of a similar program to that being considered for the Kaiser site, this section provides details of a food waste recycling program implemented in Los Angles, California.

As of June 2012, California is diverting 65% of wastes from landfills with a goal of 75% by 2020. The City of Los Angeles Restaurant Food Waste Recycling Program was established to divert food wastes from landfills. It began as a pilot program in 2005 with 300 restaurants participating. As of late 2012, 1,400 restaurants are participating, representing over 16% of food establishments in Los Angeles.

4.3.1.1 Program Information

The manager of the City of Los Angeles Restaurant Food Waste Recycling Program provided the following program information:

- 1,400 restaurants participate
- Los Angeles tracks wastes with an average of 2.5 tons per month per restaurant
- Annual collection of restaurant food wastes is estimated at 60,000 tons/year

- Pre- and post-consumer restaurant food wastes are collected
- Private waste haulers enter into a contract with Los Angeles (currently five haulers)
- Private waste haulers negotiate a contract with restaurants to collect food wastes
- Waste haulers provide bins (many are under lock and key); typical size is 3-yard bins but 90 gallon bins on wheels are available for smaller restaurants
- Waste haulers provide regular training for restaurants on separating wastes
- Collection schedule is determined between waste hauler and restaurant; it is available 7 days a week
- Los Angeles pays haulers a rebate of $45/ton, which is the same as the landfill tipping fee
- Restaurants pay a fee for organic wastes, which is less than the regular garbage rate (the rate is negotiated between the hauler and restaurant)
- Waste haulers deliver food wastes to a private compost company with a tipping fee of $50/ton of organic waste; resulting compost is sold to agriculture users.

The main driver for restaurant participation is generally reduced costs for waste disposal. The waste hauler receives $45/ton from Los Angeles and is charged $50/ton to drop off organic wastes at a composting facility. The profit to the waste hauler comes from restaurants paying for the service. Waste haulers are able to charge less for organic wastes than regular garbage due to the $45/ton rebate. Restaurants are also motivated to join when a large facility nearby joins the program. For example, when the Marriot Hotel joined, surrounding restaurants also signed up. The Los Angeles program stated there are challenges within strip malls that typically contain 8–10 businesses, two of which are usually restaurants. The strip mall landlord generally handles trash service and will not allow collection of organic wastes. Also, there has been trouble enlisting some franchise restaurants due to corporate offices handling waste contracts from out of state locations

4.4 Feedstock Summary and Conclusions

Ample feedstock is available in the surrounding region. It makes sense to begin with St. Bernard and Orleans Parishes due to proximity to the site. It is advisable to establish relationships early on in the project with primary producers, including hospitals, universities, and the largest food manufacturers. The uniformity and predictability of wastes from a few large producers will assist in forecasting feedstock volumes and content. Collection of food wastes will benefit the environment by diverting wastes known to produce methane emissions and extend the life of area landfills. While there is no cost for the feedstock, the project must establish fees that make separating organic wastes attractive for food waste generators. This may be achieved by offering a tipping rate lower than the landfill providing an incentive for waste haulers to deliver food wastes to the Chalmette site. In turn, the waste haulers can provide a more competitive rate for food wastes than regular garbage.

5 Heat and Power Markets

St. Bernard Parish is an area of heavy industry dominated by energy and shipping industries. Mississippi River ports are crucial to the delivery of petroleum products and natural gas. Residential housing units and population were significantly impacted by Hurricane Katrina in August 2005. Residential electricity demand, which commands the highest price, has not returned to pre-Katrina levels (Figure 10). Louisiana experiences energy prices significantly lower than the national average. This is due to the natural gas pricing point at Henry Hub, heavy area energy production, and local policies. Henry Hub is a natural gas distribution point in Louisiana used as the pricing point for natural gas future contracts on all major exchanges.

The recent boom in natural gas production has led to decreased prices for both heat and electricity.

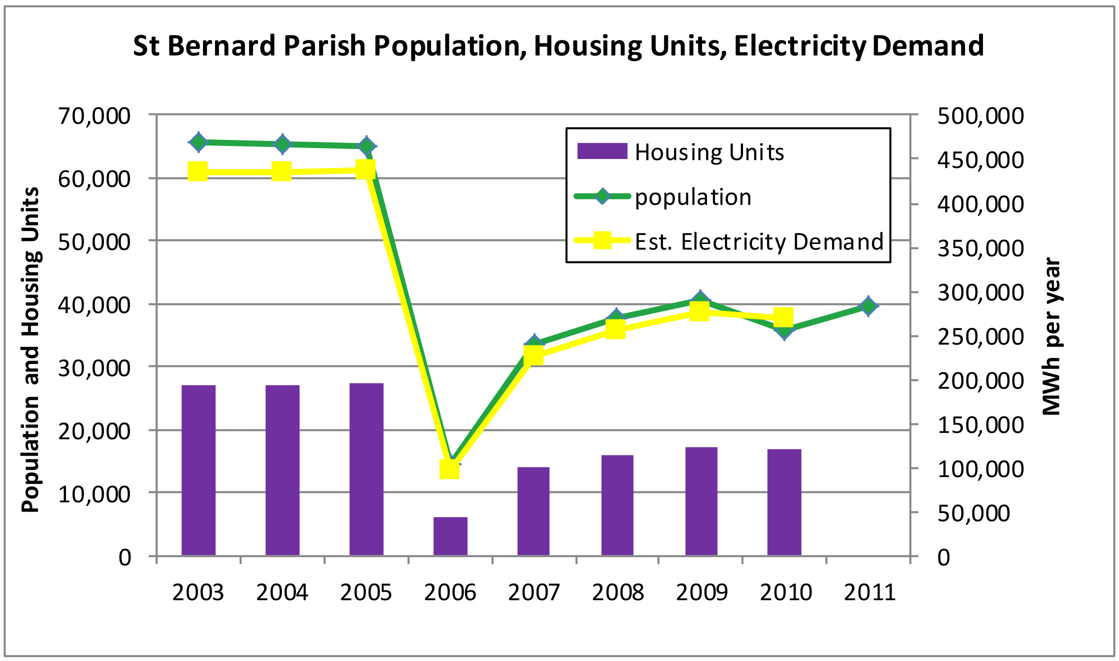

Figure 10. St. Bernard Parish population, housing, and estimated demand[40]

Renewable energy technologies tend to be more expensive than traditional energy sources. Louisiana does not have any renewable energy use mandates. However, the Louisiana Public Service Commission established a renewable energy pilot program to determine the feasibility of enacting a statewide renewable portfolio standard (requiring renewable electricity generation).[41] The program has a research component where utilities collect data on renewable energy and each investor-owned utility must develop at least three projects. These projects may be owned by the utility or the utility may establish a tariff to purchase renewable energy from independent producers. The tariff amount is set at $30/MWh plus avoided-cost payments. Additionally, both

[40] Data from the U.S. Census Bureau historical data & DOE EIA Household Fuel Consumption, South Region 2009.
[41] LA PSC Docket No. R-28271 Subdocket B. Renewable Energy Pilot Program. Louisiana Public Service Commission, November 2010. Accessed January 7, 2013: http://lpscstar.louisiana.gov/star/ViewFile.aspx?Id=870fff5f-5836-406f-a888-264776b26095.

cooperative and investor-owned utilities must issue request for proposals (RFPs) for new renewable energy sources coming online between 2011 and 2014. The maximum is 350 MW of renewable power with each utility's percentage based on 2009 sales. Entergy, the local utility, states on its website that it is opposed to mandated use of renewable energy due to price and base-load power concerns.

5.1 Power Markets

Louisiana electricity generation is dominated by natural gas as an energy source followed by coal and nuclear (Table 10). Louisiana tends to have electricity rates significantly lower than the U.S. average in all sectors (Table 11). 2011 Entergy Louisiana prices are similar for residential, higher for commercial, and lower for industrial rates when compared with average statewide rates (Figure 11). While Louisiana offers some financial incentives for solar and wind, there are no state incentives for bioheat or biopower. Entergy Louisiana consumption is dominated by the industrial sector (Figure 12). There is significant electricity production within 5 miles of the site. Three plants produced a combined 1.98 million MWh in 2011. These plants include Entergy's Michoud natural gas plant, Domino Sugar's natural gas plant (power used on-site), and CII Carbon's coke plant.[42] Additionally, Entergy plans to build a 550-MW natural gas unit in Westwego, Louisiana in 2013.

Table 10. Louisiana Electricity Generation by Source[43]

Energy Source	Generation (MWh)		% Total
Natural Gas	54,209,144		51.5%
Coal	24,608,886		23.4%
Nuclear	16,614,975		15.8%
Petroleum	4,716,393		4.5%
Wood	2,359,194		2.2%
Other Gases	1,323,511		1.3%
Hydroelectric	1,044,019		1.0%
Other	306,844		0.3%
Other Biomass	80,258		0.1%

Table 11. Current Electricity Rates Comparison[44]

Sector	LA Rank	LA	U.S. Average
		Cents per kWh	
Residential	Lowest in nation	8.12	12.12
Commercial	2nd lowest in nation	7.28	10.44
Industrial	3rd lowest in nation	4.17	6.95

42 eGRID. EPA 2010 data. Accessed January 7, 2013: http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html.
43 DOE Energy Information Agency. Accessed January 8, 2013: http://www.eia.gov/electricity/data/state/.
44 DOE EIA Average Retail Price of Electricity to Ultimate Consumers, Table 5.6.A, July 2012.

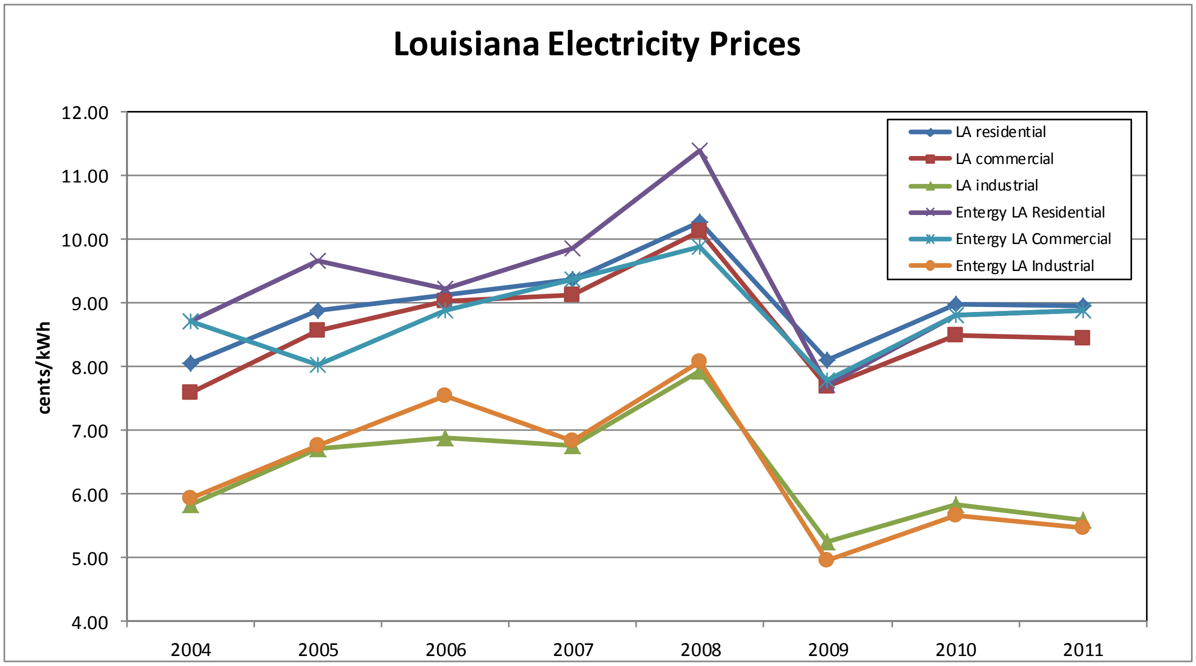

Figure 11. Electricity prices[45]

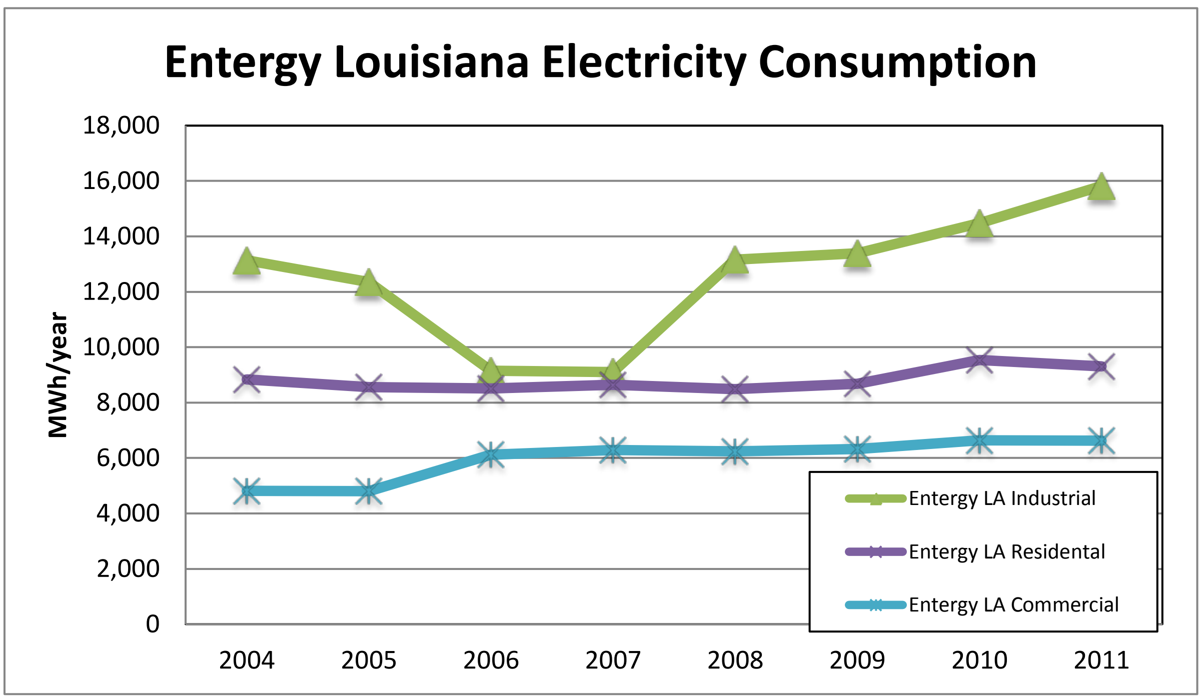

Figure 12. Electricity consumption[46]

[45] Data from DOE EIA Average Retail Price of Electricity to Ultimate Customers, By End-Use By state, Table 4 and Table 10. Accessed January 8, 2013: http://www.eia.gov/electricity/sales_revenue_price/index.cfm.
[46] Data from DOE EIA Retail Sales of Electricity to Ultimate Consumers All Sectors by State and Utility, Table 10. Accessed January 8, 2013: http://www.eia.gov/electricity/sales_revenue_price/index.cfm.

There will be challenges in marketing new biopower sources in the area due to low demand, high prices, and some industrial customers generating their own power. It needs to be determined if there are any potential energy users willing to pay a higher rate for renewable power.

5.2 Thermal Markets

Louisiana is a dominant producer of natural gas and is the national pricing point for the commodity. As shown in Figure 13, natural gas rates have diminished in the past year and Louisiana industrial rates are the lowest nationwide at $2.62 per 1,000 cubic feet (mcf). The only other state with a similar rate is Texas. Renewable heat from biomass cannot compete with this low price. However, natural gas prices, like all commodity prices, fluctuate over time. Louisiana natural gas demand is significant in industrial and electricity generation sectors and low in commercial and residential sectors (Figure 14).

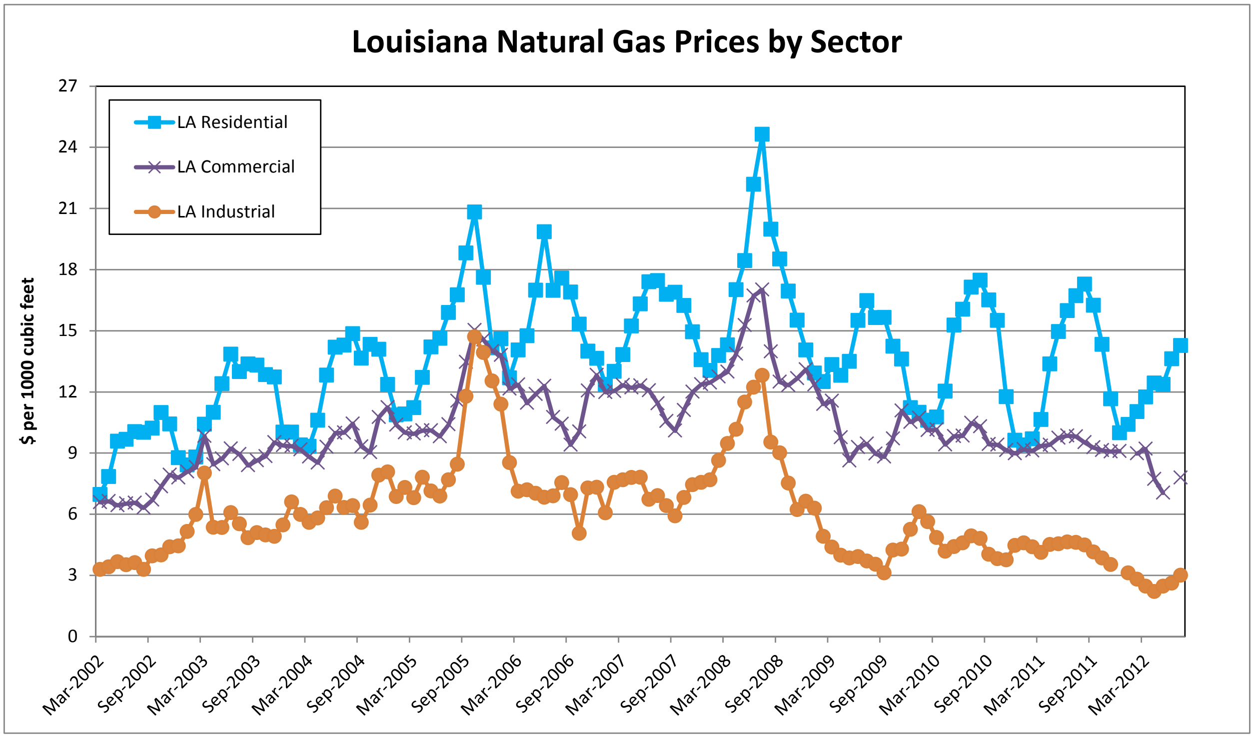

Figure 13. Natural gas prices[47]

[47] Data from DOE EIA Natural Gas Prices by Sector. Accessed January 8, 2013: http://www.eia.gov/dnav/ng/ng_pri_sum_dcu_nus_m.htm.

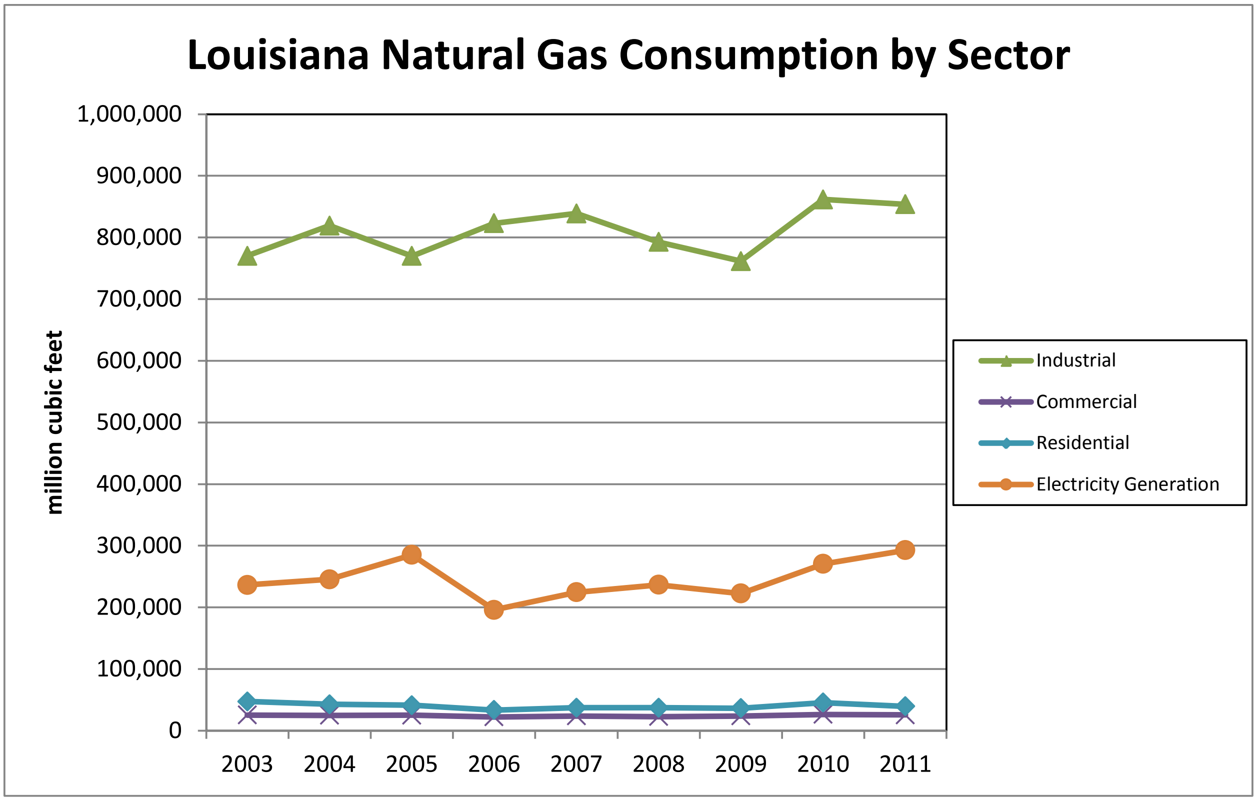

Figure 14. Natural gas consumption[48]

5.3 Market Summary

The market for renewable energy from biomass in the area surrounding the site is limited. This is due to energy prices in Louisiana far below national averages. Additionally, for a biogas project to be viable in this region, there must be customers willing to pay more for renewable power. Neither Louisiana nor Entergy, the local utility, offer incentives for renewable power.

[48] Data from DOE EIA Natural Gas Consumption by Sector. Accessed January 8, 2013: http://www.eia.gov/dnav/ng/ng_cons_sum_dcu_nus_m.htm.

6 Financial Analysis

Nearly all food-waste-based digesters in the United States are publicly owned. In many cases, the purpose of these digesters is to divert food wastes from landfills. Financial benefits of biopower may be a secondary goal. Most existing anaerobic digesters are used to treat wastewater or manure with biopower as a by-product. The upfront costs to build an AD plant are considerable as are the operation and maintenance (O&M) costs. Many projects attempt to recuperate operational costs through collection of tipping fees for wastes. As discussed in the Section 4, it is necessary to provide a tipping rate lower than the landfill to incentivize waste haulers to deliver feedstock and food waste generators to separate. Unfortunately, area landfill tipping rates are among the lowest nationally at $30/ton. Additionally, there are no state mandates or efforts to divert organic wastes from landfills. Even with a negative cost for feedstock, economics for AD facilities are challenging.

Table 12 shows cost data for several existing and planned food waste digesters. The data was obtained from CalRecycle, a California government program, and a City of Atlanta funded study.[49] The average cost for a new average size digester is $561/ton of installed capacity. This average does not include East Bay (used an existing digester) or Cedar Groove—a large facility that already owns preprocessing equipment. Less information is available for operational costs or tipping fees. The best available O&M cost data is from the East Bay project as it is operational and it is in the United States. A University of Columbia study found European capital costs were similar, although they trended downwards considerably for large plants; operational costs were high at $77–$140 per metric ton.[24] The Atlanta study estimates 2–4 jobs per 10,000 tons capacity.

Table 12. Food Waste Anaerobic Digestion Costs and Capacity

Anaerobic Digester Owner	Capacity	Capital Costs	Per Ton	Operational Costs	Tipping Fee	Energy Output
	tons/year	Million $	$/ton	$ per ton	$ per ton	
East Bay Municipal Utility District[a1]	7,500-15,000	$2-5	$266-333	$40-55	$40	220 kWh/ton
City of Toronto[1]						
Existing	40,000	$18	$450	$90		107m^3/tonne biogas
Planned	27,500	$23	$836			unknown
Planned	55,000	$34	$618			unknown
University of Wisconsin (pilot)[2]	6,000	$2.3	$383			400 kW
Cedar Grove Composting, WA[b1]	280,000	$87	$309			8 MW
Humboldt County, CA[1]	10,000	$6	$600	$34	$60	2,400 MWh/yr
w2E[3]	48,000	$23	$479		$35	3.2MW

a-used capacity in an existing digester; expenditures w ere for pre-processing and energy generation equipment

b-facility already has pre-processing equipment for composting operation

1-"Update on Anaerobic Digester Projects Using Food Wastes in North America." Institute for Local Self Reliance. City of Atlanta. October 2010.

2-Munger, A. "UW-O to get biow aste energy unit". A-T Online. February 24, 2010. http://w w w .advancetitan.com/new s/uw -o-to-get-biow aste-energy-unit-1.1174178#.UH79Y0JpLA4

3-Soberg, M. "W2E to build $23 WtE facility in SC". Biomass Magazine. September 6, 2011. http://biomassmagazine.com/articles/5774/w 2e-to-build-23-million-w te-facility-in-sc

[49] "Digesting Urban Residuals Forum Highlights." CalRecycle, May 2012. Accessed January 8, 2013: http://www.calrecycle.ca.gov/Organics/Conversion/Events/Digesting12/CaseStudies.pdf.
"Update on Anaerobic Digester Projects Using Food Wastes in North America." Institute for Local Self Reliance. City of Atlanta, October 2010.

6.1 Financial Forecast Assumptions

The Co-Digestion Economic Analysis Tool (CoEAT) was used to evaluate this project.[50] CoEAT was developed by EPA Region 9 for the purposes of analyzing the economics of biogas production when co-digesting food wastes at wastewater treatment plants in existing wet digesters. The tool is flexible and allows a user to evaluate financial performance of a standalone food-based digester. This involved only using inputs for food wastes and entering in all capital and O&M costs associated with the project. CoEAT is not designed as a rigorous financial model. It provides outputs on the feasibility of a potential AD project based on user-defined inputs.

The major variables for the financial analysis are capital costs, O&M costs, tipping fees, and sales of electricity and heat.

6.1.1 Capital Costs

Up-front costs for AD are high due to equipment necessary to produce bioenergy from a food wastes, which includes: equipment to weigh and receive feedstock, feedstock preprocessing equipment, storage of feedstock prior to digestion, digester, energy generation equipment, and hydrogen sulfide clean-up equipment. Several studies were reviewed to determine approximate installed costs for food-waste-based digesters. A price of $561/ton of installed capacity was used based on Table 12.

6.1.2 Operation and Maintenance Costs

O&M costs covers the costs for all O&M activities, including processing feedstock, employment, and chemicals. There is little O&M data currently available. This study uses average O&M costs as reported by EBMUD's costs to digest food wastes. They reported $40–$55/ton; the average used in the financial analysis is $48/ton.

6.1.3 Food Waste Quantity

Without further study and surveying, it is not possible to determine actual wastes delivered to a facility. For the purposes of this study, total food waste (Table 8) and potential collection rates (Table 9) were estimated based on a series of assumptions (see Section 4). It is assumed that a low scenario would generate 7,600 tons per year and a medium scenario would generate 15,500 tons per year. These amounts were rounded down to 7,000 and 15,000 tons expecting that some waste will be rejected in the pre-processing phase. The financial model only uses the 7,000 ton per year scenario. The financials would not be appreciably different as both are considered small plants. It is assumed a plant would receive food wastes 5 days per week.

6.1.4 Biogas Yield

The CoEAT model calculates biogas production. It assumes 15 cubic feet of biogas is produced for each pound of volatile solids destroyed. Food wastes are estimated to be 30% solid (600 lbs/ton). EBMUD established that average volatile solids content of total solids in food waste is 88.45% (531 lbs/ton). It is assumed that methane content in biogas is 60% and 10% of biogas is used as captive energy to operate the plant and associated buildings.

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[50] CoEAT. Accessed January 7, 2013: http://www.epa.gov/region9/organics/coeat/index.html.

6.1.5 Tipping Fees

A food waste tipping fee of $20/ton was used. Local landfills charge $30/ton. Tipping fees for food waste must be lower (or subsidized) to incentivize separation of wastes and collection and delivery by private waste haulers. Based on conversations with local haulers, $20/ton would likely incentivize separation of food wastes and delivery of wastes to a separate facility.

6.1.6 Electricity Sales

The electricity sales price is set at $0.078/kWh. This is the average 2011 rate for Entergy Louisiana for all sectors (residential, commercial, and industrial).

6.1.7 Heat Sales

The heating rate is set at $2.67/mcf. This is the average Louisiana industrial rate for 2012. Industrial rates were used as it is assumed that heat produced from the digester will not enter area pipelines. Instead it will be delivered directly to nearby port area users.

6.1.8 Digestate

The model used does not account for digestate sales—only costs for disposal. The literature suggests that some plants compost digestate and sell it at minimal prices as soil amendment or animal bedding. Other plants pay to landfill it. It is assumed that digestate from this project generates no revenue or costs. The model assumes digestate is given away for agricultural purposes.

6.1.9 Financing

Discount and interest rates of 10% and 7% were used. These rates vary with type of ownership and other factors.

Table 13. Financial Model Inputs

Financial Model Inputs	
Capital Costs	$561/ton
O&M Costs	$48/ton
Food Waste Volume	7,000 tons
Tipping Fee	$20/ton
Electricity Rate	$0.078/kWh
Heat Rate	$2.67/mcf
Discount Rate	10%
Interest Rate	7%
Debt Payment	15 years

Table 14. Technical Financial Model Inputs

Parameters	Low Scenario	Medium Scenario	Units
Digester Volume	92,353	197,328	ft^3
Inputs	**Value**		
Food Waste Mass	8.1	17.2	short tons/day
Food Waste Biogas Yield	6.65	6.65	ft^3 CH4/lb TS
Food Waste Total Solids (TS)	0.3	0.3	solids
Food Waste Volatile Solids (VS)	88.45%	88.45%	of total solids
Food Waste % of Total Waste	100%	100%	total substrate
Total Feedstock Loading (TS)	16,200	34,614	lbs/day
Feedstock Loading (VS)	14,329	30,616	lbs/day
Outputs			
Biogas Production Rate	15	15	ft^3 biogas/lb VS destroyed
Daily Biogas Production	190,109	406,199	ft^3 biogas/day
Annual Biogas Production	49,428,257	105,611,709	ft^3/yr
Annual Excess Biogas Available*	44,485,431	95,050,538	ft^3/yr
Methane to Biogas Ratio	0.6	0.6	
High Heat Value of Methane	1011	1,011	Btu/ft3
Heat Value Estimate	26,985	57,658	MMBtu/yr
KWh Value Estimate	1,739,866	3,717,514	KWh/yr
*10% of biogas is retained to heat and operate biodigester plant			

6.2 CoEAT Modeling Results

The high capital costs and O&M costs greatly exceed annual revenues from tipping fees and energy sales. The net present value (NPV) measures the difference between cash inflows and outflows and is a key indicator of a project's profitability potential. A 7,000 ton per year digester yielded an NPV of –$6,762,992. The project loses money each year of operation (Table 15).

Table 15. Income Statement

Income Statement	
Revenue	**$/year**
Tipping Fees	$ 140,400
Electricity Sales	$ 135,710
Heat Sales	$ 72,050
Total Revenue	$ 348,160
Expenses	
O&M	$ 336,000
EBITDA	**$ 12,160**
Less	
Debt Payments	$ 431,163
Annual Pre-Tax Income	**$ (419,003)**

The project is most sensitive to capital costs, O&M costs, and tipping fees. With all other variables remaining the same, a tipping fee of $80/ton is required for the plant to break even. Electricity and heat sales are less sensitive. The electricity break-even price, with all other variables unchanged, is $0.32/kWh. Heat sales are not significant and have a minor impact on overall economics of the plant.

The lowest capital and O&M costs in Table 12 are $309/ton installed and $34/ton O&M. These values were evaluated in CoEAT and the NPV remained negative at –$2.4 million. With these lower estimates, the project would require a tipping fee of $39/ton to break even. Several studies suggested tipping fees of $60 are necessary to cover costs to build and operate a food-based AD plant.

6.3 Project Financing

Project financing for an AD project with favorable economic performance will be difficult. There will be a perceived risk as there are few examples of food waste digesters in the United States. They are generally co-located at WWTPs. The only standalone plant in the United States is an experimental pilot plant at a university. A digester is not believed to have reuse value. This is challenging as the digester is one of the most expensive pieces of equipment, but it will not be used as collateral due to the lack of perceived reuse. It appears that high solids/dry digester technology is preferred for food wastes. However, this is a novel technology not yet proven in North America, which will be perceived as a risk to investors. Lenders generally seek proven technologies and contractors with experience building a particular type of technology. Additionally, digesters in the United States are almost universally owned by municipalities or other public entities. This type of project would likely require a loan guarantee to attract investors.

7 Conclusion

This study finds that there is adequate food waste and the site is capable of supporting a biomass facility. However, the project is projected to lose money. This is due to a combination of factors. The primary factors predicting poor financial performance include low area tipping fees and energy prices as well as high capital costs for the technology. Additionally, there is no state policy requiring renewable energy generation. Other possibilities for food wastes may include an industrial composting facility or co-digestion of food wastes at a nearby WWTP with excess capacity in their anaerobic digester.

Appendix A: Site Topography

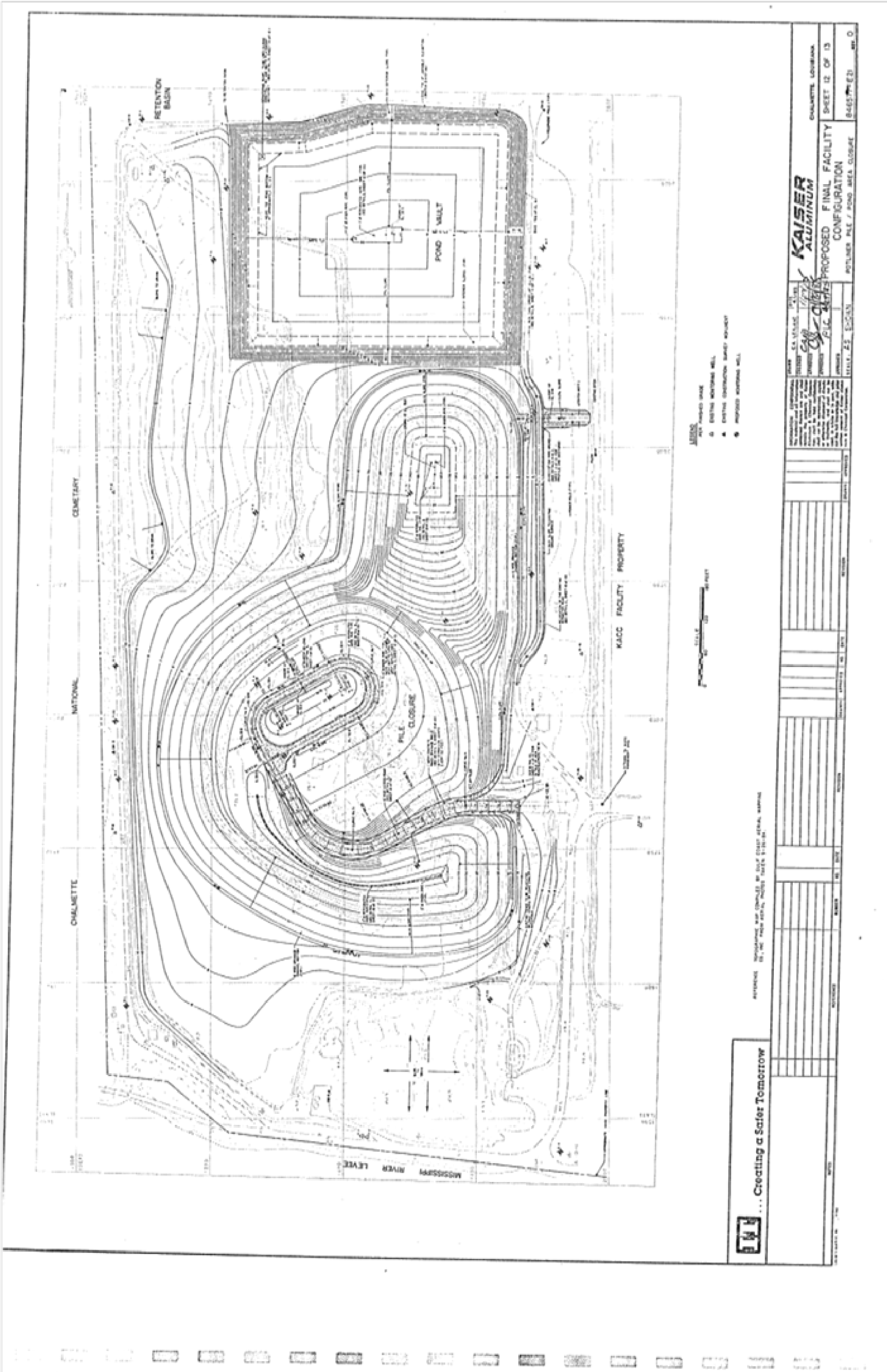

Figure A-1. Site topography. *Image from TRC*

Appendix B: Food Waste Generator Details

Table B-1. Food Waste Generator Details

Establishment Type	# of Establishments by Employment Size					Total # of Establishments
	10-19	20-49	50-99	100-249	250-499	Total
St. Bernard						
Restaurants	7	9	0	0	0	16
Grocery Stores	5	0	1	1	0	7
Food Manufacturers	0	0	0	0	0	0
Plaquemines						
Restaurants	8	6	0	0	0	14
Grocery Stores	0	1	1	0	0	2
Food Manufacturers						
Seafood Processing	0	0	0	1	0	1
Food Wholesalers						
Grain	0	0	0	1	0	1
Seafood	0	1	0	0	0	1
Orleans						
Restaurants	142	170	48	22	0	382
Grocery Stores	7	5	4	8	0	24
Food Manufacturers						
Animal Slaughtering	1	0	0	0	0	1
Bakery-Commercial	1	2	1	0	1	5
Bakery-Retail	3	0	0	0	0	3
Chocolate	0	1	0	0	0	1
Coffee/Tea	0	0	0	1	1	2
Cookie, Cracker, Pasta	1	0	0	0	0	1
Confectionary Sugar	1	0	0	0	0	1
Dairy	0	0	0	0	1	1
Dough	1	0	0	0	0	1
Meat Processor	1	0	0	1	0	2
Poultry Processor	1	0	0	0	0	1
Seafood Processor	0	1	0	0	0	1
Food Wholesales						
General Grocery	0	0	1	0	0	1
Frozen Food	0	1	1	0	0	2
Other	2	2	0	1	0	5
Seafood	0	2	0	0	0	2
Vegetables	1	0	0	0	0	1
Jefferson						
Restaurants	175	197	50	14	0	436
Grocery Stores	6	5	15	16	1	43
Food Manufacturers						
Animal Slaughtering	1	0	0	0	0	1
Bakery-Retail	1	2	0	0	0	3
Coffee	0	1	0	0	0	1
Confectionary Sugar	0	1	0	0	0	1
Fruit/Vegetable Processing	0	1	1	1	0	3
Seafood Processing	0	1	0	0	0	1
Seasoning	1	2	1	0	0	4
Food Wholesaler						
Confectionary	0	0	1	0	0	1
Dairy	2	0	0	0	0	2
Frozen Food	1	1	0	1	0	3
Fruit/Vegetable	1	1	1	0	0	3
General Grocery	2	2	1	1	0	6
Meat	1	0	1	0	0	2
Other	5	4	0	1	1	11
Seafood	2	1	0	0	0	3

Appendix C: Anaerobic Digestion Technology Providers

There are many AD technologies. Many AD companies are based in Europe and have a U.S.-based distributer. This is not an exhaustive list, but it does include many of the companies offering AD technology for food wastes.

ArrowBio
Yoqneam 20692,
ISRAEL
+972-484-11100
972-484-22200 (f)
arrowbio@arrowecology.com
www.arrowecology.com

Bekon
Feringastraße 9 D-85774
Unterföhring
+49 089- 90 77 959-0
+49 089-90 77 959-29 (f)
contact@bekon.eu
http://www.bekon.eu

BioFERM
617 N. Segoe Road, Ste. 202
Madison, WI 53705
608-467-5523
608-233-7085 (f)
http://www.biofermenergy.com

Biogas Energy, Inc.
815 301 3432
info@biogas-energy.com
http://www.biogas-energy.com/site/index.html

Canada Composting/CCI Bioenergy
390 Davis Drive Suite 301
Newmarket, ON Canada L3Y 7T8
905-830-1160
905-830-0416 (f)
kmatthews@canadacomposting.com
http://www2.ccibioenergy.com

Clean World Partners
2330 Gold Meadow Way
Gold River, CA 95670
800-325-3472
http://www.cleanworldpartners.com

DRANCO/OWS Inc.
7155 Five Mile Road
Cincinnati, OH 45230
USA
513-535-6760
513-233-3395 (f)
norma.mcdonald@ows.be
http://www.ows.be/pages/index.php?menu=69&choose_lang=EN

Ecocorp
626-405-1463
jgingersoll@ecocorp.com
www.ecocorp.com

Entec Biogas USA
Schilfweg 1
6972 Fussach Austria
Austria
+43-5578-7946
+43-5578-7946-800 (f)
office@entec-biogas.at
http://www.entec-biogas.com/en/

Harvest Power
221 Crescent St. Suite 402
Waltham, MA 02453
781-314-9500
http://www.harvestpower.com

New Bio
7679 Washington Ave S.
Edina, MN 55439
952-476-6194
952-476-8622 (f)
http://www.newbio.com

Orgaworld
5123 Hawthorne Road
Gloucester, ON K1G 3N4
Canada
613-822-2056
613-822-2058 (f)
http://www.orgaworld.nl

Quasar Energy Group
2705 Selby Road
Wooster, OH 44691
(216) 986-9999
projectdevelopment@quasarenergygroup.com
http://www.quasarenergygroup.com

Ros Roca Envirotec
PCiTAL Gardeny
Edifici H2 Planta 2a
25003 Lleida
Spain
+34-973-100-801
http://www.rosrocaenvirotec.com/RosRocaWeb.html

Valorga
SAS au capital de 600 000 € -
RCS 444 540 496
1140 avenue Albert Einstein -
BP 51
F 34935 Montpellier Cedex 09
France
+33-0-4-67-99-41-00
+33-0-4-67-99-41-01 (f)
contact@valorgainternational.fr
http://www.valorgainternational.fr/en/

Zero Waste Energy, LLC (Kompoferm)
3470 Mt. Diablo Blvd. Suite A215
Lafayette, CA 94549
925-297-0600
http://zerowasteenergy.com